The impact of local and global oil price shocks on stock market returns and exchange rates: Evidence from oil-importing and oil-exporting countries

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The impact of local and global oil price shocks on stock market returns and exchange rates: Evidence from oil-importing and oil-exporting countries

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In this thesis, we examine whether the impacts of local and global oil price shocks on stock market returns and exchange rates in oil-exporting countries are different from those in oil-importing countries. We construct global oil price shocks using a structural vector autoregressive model (SVAR) developed by Kilian (2009); local oil price shocks are constructed following Ready's (2018) approach using ordinary least squares (OLS) regression. Our findings show that local oil price shocks and global oil price shocks have different impacts on both stock market returns and exchange rates depending on the level of oil dependence of each country and the source of oil price changes. Changes in oil prices driven by local and global demand shocks have a positive effect on stock market returns in both oil-exporting and oil-importing countries. On the other hand, the impact of local and global supply shocks on stock market returns is mixed. Interestingly, local supply shocks have a significantly stronger impact than global supply shocks. In addition, our results on the relationship between oil price shocks and exchange rates show that local demand and local supply shocks contribute to the appreciation of oil-exporters' currency while these local shocks lead to depreciation of oil-importers' currency. Moreover, global demand shocks lead to U.S. dollar appreciation while there is depreciation in the U.S. dollar following global supply shocks.

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Abstract

In this thesis, we examine whether the impacts of local and global oil price shocks on stock market returns and exchange rates in oil-exporting countries are different from the impacts in oil-importing countries. We construct global oil price shocks using a structural vector autoregressive model (SVAR) developed by Kilian (2009); local oil price shocks are constructed following Ready's (2018) approach using ordinary least squares (OLS) regression. Our findings show that local oil price shocks and global oil price shocks have different impacts on both stock market returns and exchange rates depending on the level of oil dependence of each country and the source of oil price changes. Changes in oil prices driven by local and global demand shocks have positive effects on stock market returns in both oil-exporting and oil-importing countries. On the other hand, the impact of local and global supply shocks on stock market returns is mixed. Interestingly, local supply shocks have a significantly stronger impact than global supply shocks. In addition, our results on the relationship between oil price shocks and exchange rates show that local demand and local supply shocks contribute to the appreciation of oil-exporters' currency while these local shocks lead to depreciation of oil-importers' currency. Moreover, global demand shocks lead to U.S. dollar appreciation while there is depreciation in the U.S. dollar following global supply shocks.

CHAPTER 1
Introduction

The price of crude oil is considered to be a significant factor affecting the economy. Many researchers have studied oil price fluctuations in order to understand their economic impacts. Not surprisingly, a large body of literature has studied the relationship between oil price shocks and economic variables. In particular, macroeconomic variables such as oil price shocks can lead to higher inflation or lower economic growth (see e.g., Barsky & Kilian 2004; Hamilton 1983, 2003; Peersman & Robays 2009). Moreover, most of the existing studies are focused on the United States (U.S.) or European markets, where there are the important oil-importing countries in the world[1]. However, the impact of oil price shocks across countries differs depending on the country's economic structure, such as the level of oil dependence, its monetary policy[2] or the effect of the country's economic development on the global economy. Thus, a possible concern is that the linkage between oil prices and national economies of oil-exporting countries may be different from oil-importing countries.

Even though the relationship between oil prices and the macroeconomy or macroeconomic variables has been extensively studied, another body of literature which studies the impact of oil price shocks on stock market returns is also significantly important. Theoretically, oil price shocks can be transmitted to stock

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[1] See Bastianin, Conti and Manera (2016).

[2] The magnitude of the effect of oil price shocks may depend on the credibility of the central bank to stabilise inflation. If the central bank has high (low) creditability, the inflation expectation will be stable (volatile) following oil price increases, leading to effects on the economy.

markets through production cost effects (see e.g., Brown & Yucel 1999; Oberndorfer 2009) or income effects (see e.g., Bernanke 2006; Svensson 2005, 2006). Moreover, the main channel in which oil price fluctuation may be transmitted to the economy is through exchange rates, and thus, the literature has focused on the relationship between oil prices and exchange rates. The U.S. dollar exchange rate is the major settlement currency for global oil trading. Thus, the impact of oil price shocks on stock market returns and exchange rates is important to study.

Interestingly, the impact of oil price shocks on stock market returns and exchange rates is mixed in previous studies. A plausible explanation is that such oil price impacts differ between oil-importing countries and oil-exporting countries. Further, the sources that cause oil price fluctuation trigger different impacts on stock market performance and the value of currency. Studying the reaction of stock markets and exchange rates to variations in crude oil price driven by different shocks, across different economies in different countries, is critically important and can provide valuable insight for policy making.

In this thesis, we aim to investigate the impact of oil price shocks, driven by different sources, on major oil-importing and oil-exporting countries. We do this by using two methodologies for constructing local and global oil price shocks. First, we construct global oil price shocks using a structural vector autoregressive model (SVAR) adopted by Kilian (2009) to classify oil price shocks into three drivers: supply shocks, aggregate demand shocks and oil-specific demand shocks. Second, local oil price shocks are constructed by Ready's (2018) approach using Ordinary Least Squares (OLS) regression to decompose oil price shocks into supply shocks, demand shocks and risk shocks. Then, we examine the impact of local oil price shocks and global oil price shocks driven by supply and demand shocks on stock market returns and exchange rates of oil-importing and oil-exporting countries. The main purpose of this analysis is to examine whether local oil price shocks using Ready's (2018) approach and global oil price shocks using Kilian's (2009) approach have different relationships with stock markets returns and exchange rates.

There is a vast body of literature that has used oil price constructions according to Kilian (2009). These studies have reported that stock market returns have a relatively low response to oil supply shocks, compared to oil demand shocks, in most countries (see e.g., Basher et al. 2012; Degiannakis et al. 2014; Filis et al. 2011; Kang et al. 2015a; Wang et al. 2013). On the other hand, there has not been any further research based on Ready's (2018) findings. Ready (2018) only examined the effects of oil price shocks on the U.S. stock market and found a negative relationship between oil supply shocks and stock market returns. Thus, it is of interest to extend the analysis of Ready (2018) to other countries that have major impacts on the global economy. Unlike the existing literature, we can construct local oil price shocks using Ready's (2018) framework, and can compare these with global oil price shocks. In addition, this study brings together two different streams of literature, that on the relationship between oil prices and stock market returns and that on the relationship between oil prices and exchange rates.

Our results indicate that local oil price shocks and global oil price shocks have different impacts on both stock market returns and exchange rates, depending on the level of oil dependence of each country and the source of oil price changes. Changes in oil prices driven by local oil demand shocks and global oil demand shocks have positive effects on stock market returns. This is consistent with Kilian and Park (2009) and Wang et al. (2013) who argue that oil demand shocks have stronger and more persistent effects on increasing stock market returns. However, it is noteworthy that local demand shocks have significantly stronger impacts than global demand shocks. Moreover, the relationship between oil supply shocks and stock market returns is inconclusive for both local and global supply shocks. We found a positive effect of local supply shocks on stock market returns in oil-exporting countries while there was both negative and positive relationships in oil-importing countries. On the other hand, the response of stock markets to global supply shocks is insignificant in most countries. This is in line with the findings of Kilian (2009) where global oil supply shocks were found to have a relatively small contribution to changing oil prices.

In addition, our finding on the relationship between oil price shocks and exchange rates indicates that both local demand and local supply shocks contribute to the appreciation of oil-exporters' currency while these local shocks lead to depreciation of oil-importers' currency. On the other hand, global demand shocks lead to U.S. dollar appreciation while there is depreciation of the U.S. dollar following global supply shocks. Moreover, it is noteworthy that global supply shocks and global demand shocks have less of an impact on exchange rates than local oil price shocks, in both oil-exporting and oil-importing countries.

The remaining part of this thesis is organised as follows. Section 2 describes the literature review related to this work. Section 3 provides a description of the data. Section 4 describes the empirical methodology for shock construction applied in this study. Section 5 presents and discusses the empirical results. Finally, Section 6 provides conclusions based on the main findings of the analyses.

CHAPTER 2
Literature review

There are several previous empirical studies examining whether oil price shocks affect the economy. Initially, these studies focused on how oil price shocks affect major macroeconomic variables such as Gross Domestic Product (GDP), interest rates, exchange rates and inflation. Hamilton (1983) found that oil price changes have a significant negative impact on U.S. economic activity as oil price shocks can drive higher inflation and lower real output levels; this causes a depression in economic growth and exchange rates. Similarly, Sadorsky (1999) examined the impact of oil price volatility shocks on the U.S. economy and found that changes in oil prices have a negative effect on macroeconomic variables such as interest rates and industrial production. Mork (1989), based on the U.S. market, concluded that economic activities and oil prices have an asymmetric relationship. Chen and Chen (2007) reported that real oil prices have a significant impact on real exchange rate movement in G7 countries. Mork et al. (1994), Ferderer (1996), Lee et al. (2001) and Hooker (2002) have all performed similar research in different countries.

Extant studies have taken a broad perspective to analyse the relationship between oil prices and exchange rates. In international oil markets, the exchange rate is the primary channel in which oil price shocks may be transmitted to the economy and financial markets. Krugman (1980) and Golub (1983) are the primary contributors to the development of a theoretical model to examine why oil price changes affect exchange rates. Amano and Norden (1998) investigated the link between oil prices and exchange rates. Their findings indicated that there is a stable linkage between these two variables, implying that oil price is the dominant source of shocks on U.S. real exchange rates. Subsequently, a large body of literature has reported similar results, confirming that oil price shocks are an important source of exchange rate fluctuations (see Backus & Crucini 2000; Chaudhuri & Daniel 1998; Dibooglu & Koray 2001; Fratzscher et al. 2014; Habib et al. 2016).

Although several studies have found a significant relationship between oil prices and exchange rates, the empirical literature is inconsistent on whether this relationship is positive or negative. Coudert et al. (2008) explored the relationship between real oil prices and U.S. real effective exchange rates and found a positive relationship, suggesting that higher oil prices are linked to U.S. dollar appreciation through the U.S. net foreign asset position. Akram (2004), Chen and Chen (2007), Bénassy-Quéré et al. (2007) and Ghosh (2011) also found that oil price increases can generate an appreciation in the dollar exchange rate to restore the trade balance. For example, Bénassy-Quéré et al. (2007) examined the causality from real oil price to real U.S. dollar exchange rate; their results suggest that in the long term, if the oil price increases by 10%, the U.S. dollar exchange rate will depreciate by 4.3%. In contrast, a number of studies have found a negative relationship between oil prices and exchange rates. For instance, Aloui et al. (2013) estimated the conditional dependence structure between oil prices and the U.S. exchange rate using a copula-generalized autoregressive conditional heteroskedasticity (GARCH) approach. The authors found that oil price increases are associated with depreciation of the U.S. dollar. Akram (2009) investigated the Organisation for Economic Co-operation and Development (OECD) markets and found that depreciation in the U.S. dollar and a decrease in real interest rates leads to higher commodity prices, including oil prices.

In fact, the inconsistent findings on the appreciation or depreciation of the U.S. dollar exchange rate following rises in oil prices may be due to the level of oil dependence of each country. Lizardo and Mollick (2010) examined the relationship between oil price movement and the U.S. dollar against major currencies. They found that higher oil prices contribute to a significant depreciation of the U.S. dollar relative to net oil exporter currencies (Canada, Russia and Mexico), while the value of the U.S. dollar appreciated relative to net oil importer currencies (Japan).

As shown above, the price of crude oil has a significant effect on the economy; thus, changes in the oil price can be considered to be an important factor influencing financial markets. Research examining the relationship between oil prices and stock markets is still growing and the published findings are inconclusive. On the one hand, there is a bulk of literature reporting a negative impact of oil price shocks on stock market returns. For instance, Ferson and Harvey (1995), one of the earliest studies in this area, investigated the effect of oil prices on world stock market returns using the beta pricing model and reported negative effects. Jones and Kaul (1996) reported that oil price shocks have a negative impact on stock market returns in the U.S., Canada, Japan and the United Kingdom (U.K.). Oil price shocks on U.S. and Canadian stock markets are completely accounted for by their impact on cash flows, while the effects are not fully accounted for in Japan and U.K. stock prices.

Authors like Sadorsky (1999), Papapetrou (2001) and Park and Ratti (2008) also found a negative relationship between oil price shocks and equity market returns. Sadorsky (1999) examined the dynamic relationship between oil price volatility and real stock market returns in the U.S. He found that oil price shocks have a negative effect on real stock return and the effects of oil price movement explained a larger fraction of variance in real stock returns after 1986. In related work, Papapetrou (2001) examined the emerging stock market in Greece. The author found that oil prices are a significant factor in explaining stock price movements and that positive oil price shocks lead to decreases in real stock returns. Park and Ratti (2008) examined the U.S. and 13 European countries and found that oil price shocks considerably decrease real stock returns contemporaneously.

On the other hand, Sadorsky (2001) found that oil price changes have a positive effect on the stock return of oil and gas companies. This finding is supported by the findings of Yurtsever and Zahor (2007) who examined the impact of oil price shocks on stock prices in the Netherlands and found that oil price changes have a positive effect on stock market returns. However, other studies did not find any evidence of a relationship between oil prices and aggregate stock market returns. For instance, the study of Huang et al. (1996) found that no correlation between oil future returns and stock market returns. Chen et al. (1986) examined the effect of oil price changes on U.S. stock market returns and found that oil prices have no impact on stock returns. Cong et al. (2008) investigated the relationship between oil shocks and market returns in China and obtained similar findings. Jammazi and Aloui (2010) examined the impact of crude oil shocks on stock market returns in the U.K., France and Japan, and reported that crude oil shocks have no effect on stock market returns in their sample countries, except for Japan.

The reason for these inconclusive findings may be because of characteristics of the different countries, such as level of import or export and whether they are developed countries or developing countries. There is a large body of empirical research investigating the relationship between oil price shocks and stock market returns in oil-importing countries, especially in the U.S. market (e.g., Chen 2010; Degiannakis et al. 2013; Jones & Kaul 1996; Kaul & Seyhun 1990; Kilian & Park 2009). In contrast, there is little research on the relationship between oil price shocks and stock market returns in oil-exporting countries. Jung and Park (2011) examined stock market return reactions to oil price shocks in Norway (oil-exporting country) and Korea (oil-importing country) and found that oil price shocks in these two countries have heterogeneous effects on stock market returns. This finding is supported by Bjornland (2009) and Jiménez-Rodríguez and Sánchez (2005) who reported that the stock market in Norway, which is a net oil exporter, has a positive relationship with oil price increases. Moreover, the economy in Norway benefits from higher oil prices, experiencing aggregate demand, increases in aggregate wealth and decreases in the unemployment rate.

To date, most studies that focus on the oil price effect of oil-exporting and oil-importing countries in the same study confirm that the impact of oil price shocks on the stock market is different for oil-exporting countries compared to oil-importing countries. Wang et al. (2013) reported that the effect of oil price shocks on stock returns is stronger in oil-exporting countries than in oil-importing countries. This is because an increase in oil prices tends to transfer aggregate wealth from oil-importing countries to oil-exporting countries. Consequently, it pushes stock prices to increase. Moreover, there is a vast body of literature indicating that higher oil prices can lead to higher stock market returns in oil-exporting countries, while leading to a decline in stock market returns in oil-importing countries (see e.g., Arouri & Rault 2012; Hammoudeh & Li 2005; Filis & Chatziantoniou 2014; Jung & Park 2011; Lescaroux & Mignon 2008; Mohanty et al. 2011; Park & Ratti 2008).

Another important reason behind this inconclusive relationship is that most of the previous studies have not examined causes of oil price changes when analysing the impact on stock returns. For example, Kling (1985) and Jones and Kaul (1996), using total stock price variation, reported that crude oil prices have a negative relationship with stock market behaviour. The latter study addressed this limitation by classifying the causes of oil price shocks into supply and demand shocks separately, because demand and supply driven shocks on oil prices lead to different effects on stock market returns. Kilian (2009) introduced methodology to classify oil price shocks using SVAR to decompose the price of crude oil into three components: crude oil production as a proxy for supply shocks, real economic activity which is measured by shipping prices as a proxy for demand shocks and the last shock, precautionary demand shocks, captures concern that there will be a shortfall in the future oil supply. The limitations of this model are that the vertical oil supply curve has several assumptions, including that there are unpredictable innovations to oil production and oil supply does not respond to demand shocks within the same month. Kilian's (2009) findings showed that increasing aggregate oil demand shocks and oil-specific demand shocks leads to persistent and highly significant increases in oil prices, but oil supply shocks can only generate small increases in oil prices.

This methodology framework has been very popular among subsequent studies. Several studies have used Kilian's (2009) methodology to analyse the relationship between oil price changes driven by demand and supply shocks and stock market returns. Kilian and Park (2009) extended Kilian's (2009) methodology to examine oil price shocks in the U.S. stock market. They found that the response of the stock market to oil price changes is different depending on the cause of oil price shocks. Oil prices driven by precautionary demand shocks have a negative impact on U.S. market returns while higher oil prices driven by unanticipated economic expansion or demand shocks lead to a positive effect on stock returns. Finally, the authors reported no significant response of stock prices to oil price shocks if oil price changes are driven by oil supply shocks. Fang and You (2014) used this approach on three emerging markets, China, India and Russia, to examine the impact of oil price shocks driven by demand and supply on newly industrialised economic (NIE) stock markets. The authors found that the impact of oil price shocks varied depending on the country. Oil demand shocks had a significant negative impact on Russian and Indian stock market returns while there was no significant effect on China's stock market because of the efficiency of the Chinese stock market. Furthermore, there is a vast amount of existing literature using Kilian's (2009) methodology to investigate the impact of the different sources of oil price shocks on different countries (see e.g., Apergis & Miller 2009; Barsky & Kilian 2004; Bjornland 2009; Filis & Chatziantoniou 2014; Jung & Park 2011; Park & Ratti 2008; Raghavan 2015; Talukdar & Sunyaeva 2011).

In addition, there are few studies that examine the impact of oil supply and oil demand shocks on exchange rates using Kilian's (2009) methodology. Atem et al. (2015) used a two-stage approach to disentangle oil shocks into supply and demand shocks and examined their effects on exchange rates. Their analysis showed that oil supply shocks have no significant effect on exchange rates whereas oil demand shocks lead to depreciation in U.S. dollar. Basher et al. (2016) used a Markov-switching model after constructing oil shocks using Kilian's (2009) framework. They detected significant appreciation of exchange rates after oil demand shocks in oil-exporting countries. This result is supported by Su et al. (2016) and Habib et al. (2016).

Nevertheless, there are several limitations of shock construction using Kilian's (2009) framework. Kaufmann and Kolodzeij (2014) investigated Kilian's (2009) report and reconsidered the specifications for classifying oil demand and oil supply shocks. The authors reported that the measure of oil prices in Kilian's (2009) framework includes transportation costs, which can lead to unreliable results. In addition, the proxy for oil production, which aggregates both OPEC and non-OPEC oil productions, is not a significant proxy for oil supply as OPEC and non-OPEC nations have different criteria to set oil production levels. Ready (2018) used Kilian's (2009) methodology to identify the impact of the three structural oil price shocks on the U.S. market in the period from 1986-2011. Ready (2018) found that aggregate supply and demand shocks contribute approximately 2% each to the total variance in oil price, while unexplained variation captured by precautionary demand shocks contributes to 77% of the total variance. Ready (2018) concluded that demand and supply shocks explain little in the model of Kilian (2009), and thus, there must be other sources of variation which cannot be explained by the model. Another limitation is that Kilian (2009) used dry cargo single voyage ocean freight rates to capture demand on the global economy. However, Kaufmann (2011) reported that there is no statistical relationship between the freight rate index and oil consumption. Thus, it must be considered whether cargo ocean freight rates can represent global oil consumption.

Therefore, Ready (2018) proposed a new methodology. This methodology assumes that oil production is a depletable resource, and oil producer returns was constructed as a proxy for demand shocks; the remaining variation in oil prices was constructed as a proxy for supply shocks. Ready's (2018) methodology also classifies oil price shocks into three types of shocks: supply shocks, demand shocks and risk shocks. The latter type is discount rate shocks which affect the profits of oil producer returns without creating a large impact on oil prices. Ready (2018) examined the effect of oil price shocks on U.S. stock market returns. Both supply and demand shocks were found to have a different impact on equity returns. Supply shocks had a significant negative impact on U.S. stock market returns while oil demand shocks had a significant positive impact on stock returns. This result is in contrast with the results of Kilian and Park (2009) which did not find any significant relationship between U.S. stock market returns and oil supply shocks; though, the relationship between demand shocks and stock returns is consistent with Kilian and Park (2009).

Based on the above review of the literature, it is clear that there is no existing research conducted using Ready's (2018) approach to examine how oil price shocks affect stock market returns and exchange rates in other countries. Moreover, there is no empirical work confirming that Ready's (2018) methodology for oil shock construction can better explain oil price shocks. Interestingly, the shock construction of Ready (2018) can capture local oil price shocks by using local variables in each country, while Kilian's (2009) methodology captures only global oil price shocks. To respond to this, this thesis classifies the sources that cause oil price changes using Kilian's (2009) and Ready's (2018) framework, and examines the different effects of local oil price shocks and global oil price shocks on stock market returns and exchange rates in oil-importing and oil-exporting countries in order to compare the results in each different country.

CHAPTER 3
Methodology

This section briefly explains the framework for shock construction and identifies the assumptions of the model and the methodology. As discussed in the previous section, we construct oil price shocks following two approaches. First, the SVAR model described by Kilian (2009) is used to construct the structural shocks. Second, Ready (2018) claimed that Kilian's (2009) methodology has some drawbacks; thus, Ready (2018) introduced new methodology for constructing oil price shocks. The purpose of constructing shocks using two methodologies is to allow comparison of the results of SVAR and alternative methodologies.

3.1 Shock construction: Kilian's (2009) methodology

3.1.1. Structural vector autoregressive model (SVAR)

We adopt the model framework of Kilian (2009) which uses an SVAR model to disaggregate oil price shocks into three types of shocks, namely, supply shock, global aggregate demand shock and oil-specific demand shock (oil precautionary demand shock).

The starting point for estimation of the SVAR model is the estimation of the vector autoregressive (VAR) model using OLS methodology as follows:

$$X_t = C_1 X_{t-1} + C_2 X_{t-2} + \ldots + C_n X_{t-n} + e_t \tag{1}$$

where X_t is a $(n \times 1)$ vector of variables and C_i is $(n \times n)$ coefficient matrix for i = 0,1,2,3,..,n. and e_t is $(n \times 1)$ vector of error terms, which have zero means ($\mathrm{E}(\mathrm{e_t})$ = 0) and constant variances. Moreover, the variance-covariance of error terms is defined as follows:

$$\mathrm{E}(\mathrm{e_t}\acute{\mathrm{e_t}}) = \Sigma_e = \begin{bmatrix} \sigma_{11} & \cdots & \sigma_{1n} \\ \cdots & \ddots & \cdots \\ \sigma_{n1} & \cdots & \sigma_{nn} \end{bmatrix} \tag{2}$$

where Σ_e is a variance-covariance of error terms. The critical point to note is that the shocks from the VAR model (e_t) are correlated (see Lutkepohl 2005).

From the simple VAR model, we construct the SVAR model to allow for the contemporaneous relationship among variables by placing restrictions on the structural coefficient or matrix A; this can be defined as:

$$AX_t = B_1X_{t-1} + B_2X_{t-2} + \ldots + B_nX_{t-n} + u_t \tag{3}$$

where A is the matrix of the contemporaneous interaction between the variables in the model. Matrix B_i for $(n \times n)$ coefficient matrix for i = 0,1,2,3,..,n are structural coefficients which are different from their general form. The error terms (u_t) denote mean zero serially uncorrelated error terms and refer to structural shock or structural innovation. In the thesis, there is a vector of three variables (n = 3); thus, the variance-covariance matrix of structural shock is a (3×3) matrix and is assumed to be:

$$E(u_tu_t') = \Sigma_u = I = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{4}$$

Since the structural shocks are mutually uncorrelated and independent of each other, the variance-covariance matrix of structural shocks is a unity matrix.

Next, we derive the reduced-form representation to estimate the structural model by pre-multiplying the inverse of A or A^{-1} on both sides of the structural VAR model or equation (3):

$$A^{-1}AX_t = A^{-1}B_1X_{t-1} + A^{-1}B_2X_{t-2} + \ldots + A^{-1}B_nX_{t-n} + A^{-1}u_t \tag{5}$$

$$X_t = A^{-1}B_1X_{t-1} + A^{-1}B_2X_{t-2} + \ldots + A^{-1}B_nX_{t-n} + A^{-1}u_t \quad (6)$$

From equation (6), it can be defined that:

$$C_i = A^{-1}B_i \quad (7)$$

$$e_t = A^{-1}u_t \quad (8)$$

Comparing equation (6) to equation (1), it can be seen that the system is restricted. These two equations have the same formula; we can rewrite equation (6) to equation (9).

$$X_t = C_1X_{t-1} + C_2X_{t-2} + \ldots + C_nX_{t-n} + e_t \quad (9)$$

This allows us to obtain a consistent estimate of the reduced-form VAR model as in equation (1). It is clear that we cannot interpret the reduced-form errors (e_t) as the structural shocks (u_t) because the reduced-form shocks are not orthogonal and do not correspond to structural shocks as they are contemporaneously correlated. However, the structural shocks are orthogonal or serially uncorrelated and independent to each other. Thus, we need to know the structural shocks to learn about the structure of the economy and to classify the shocks.

To recover the structural shocks, we need to know the element of A^{-1} because it enables us to recover the coefficient of the model and the structural shocks from the residuals of VAR (e_t). From equation (7) and (8), it can be implied that:

$$B_i = \mathrm{A}C_i \quad (10)$$

$$u_t = \mathrm{A}e_t \quad (11)$$

By construction, the variance of reduced-form shocks is $\mathrm{E}(\mathrm{e_t}\mathrm{e_t'}) = \Sigma_\mathrm{e}$ and we can substitute the equation: $\mathrm{e_t} = \mathrm{A^{-1}u_t}$ into:

$$\Sigma_e = \mathrm{E}(\mathrm{e_t e_t'}) \tag{12}$$

$$\Sigma_e = A^{-1}E(u_t u_t')A_t^{-1'} \tag{13}$$

$$\Sigma_e = A^{-1}\Sigma_u A_t^{-1'} \tag{14}$$

From equation (4), the variance-covariance matrix of structural shocks can be defined as the identity matrix. Thus, we can substitute Σ_u with I in equation (14)

$$\Sigma_e = A^{-1}IA_t^{-1'} \tag{15}$$

or we can write in matrix form:

$$\begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} \\ \sigma_{12} & \sigma_{22} & \sigma_{23} \\ \sigma_{13} & \sigma_{23} & \sigma_{33} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}^{-1} \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}^{-1'} \tag{16}$$

Assuming $\hat{A} = A^{-1}$, we can rewrite equation (16) as:

$$\begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} \\ \sigma_{12} & \sigma_{22} & \sigma_{23} \\ \sigma_{13} & \sigma_{23} & \sigma_{33} \end{bmatrix} = \begin{bmatrix} \hat{a}_{11} & \hat{a}_{12} & \hat{a}_{13} \\ \hat{a}_{21} & \hat{a}_{22} & \hat{a}_{23} \\ \hat{a}_{31} & \hat{a}_{32} & \hat{a}_{33} \end{bmatrix} \begin{bmatrix} \hat{a}_{11} & \hat{a}_{12} & \hat{a}_{13} \\ \hat{a}_{21} & \hat{a}_{22} & \hat{a}_{23} \\ \hat{a}_{31} & \hat{a}_{32} & \hat{a}_{33} \end{bmatrix}' \tag{17}$$

where Σ_e, the variance-covariance matrix, can be estimated consistently using OLS. Since the variance-covariance matrix of the reduced-form error (Σ_e) is symmetric, there are only six equations on the left-hand side of equation (17) but we have nine unknown parameters in the element of A^{-1}. Thus, the number of unknown parameters exceeds the number of independent equations.

$$\sigma_{11} = \hat{a}_{11}^2 + \hat{a}_{12}^2 + \hat{a}_{13}^2 \tag{18}$$

$$\sigma_{12} = \hat{a}_{11}\hat{a}_{21} + \hat{a}_{12}\hat{a}_{22} + \hat{a}_{13}\hat{a}_{23} \tag{19}$$

$$\sigma_{13} = \hat{a}_{11}\hat{a}_{31} + \hat{a}_{12}\hat{a}_{32} + \hat{a}_{13}\hat{a}_{33} \tag{20}$$

$$\sigma_{12} = \hat{a}_{11}\hat{a}_{21} + \hat{a}_{12}\hat{a}_{22} + \hat{a}_{13}\hat{a}_{23} \tag{21}$$

$$\sigma_{22} = \hat{a}_{21}^2 + \hat{a}_{22}^2 + \hat{a}_{23}^2 \tag{22}$$

$$\sigma_{23} = \hat{a}_{21}\hat{a}_{31} + \hat{a}_{22}\hat{a}_{32} + \hat{a}_{23}\hat{a}_{33} \tag{23}$$

$$\sigma_{13} = \hat{a}_{11}\hat{a}_{31} + \hat{a}_{12}\hat{a}_{32} + \hat{a}_{13}\hat{a}_{33} \tag{24}$$

$$\sigma_{23} = \hat{a}_{21}\hat{a}_{31} + \hat{a}_{22}\hat{a}_{32} + \hat{a}_{23}\hat{a}_{33} \tag{25}$$

$$\sigma_{33} = \hat{a}_{31}^2 + \hat{a}_{32}^2 + \hat{a}_{33}^2 \tag{26}$$

As in the equations above, there are three sets of equations which are identical, equation (19) and (21), equation (20) and (24) and equation (23) and (25); thus, there are six independent equations to solve for nine unknowns. As such, it is not possible to solve the structural parameters because the system is not identified.

3.1.2. Identification

To solve the identification problem, we need to impose three restrictions on the parameters of the SVAR to identify the model and estimate the structural parameters. The most common approach to identify the model is to use the type of recursive system proposed by Sims (1980). This approach comes from the idea that there is a timing of effect based on economic shocks. Sims (1980) imposed a recursive order, namely Cholesky decomposition, as additional restrictions on the system to recover the structural shocks (u_t) from the reduced-form shocks (e_t) by orthogonalising the reduced-form error to be uncorrelated, according to the following scheme:

$$A^{-1} = \begin{bmatrix} \hat{a}_{11} & 0 & 0 \\ \hat{a}_{21} & \hat{a}_{22} & 0 \\ \hat{a}_{31} & \hat{a}_{32} & \hat{a}_{33} \end{bmatrix} \tag{27}$$

This Cholesky decomposition requires all elements above the diagonal to be zero; thus, we impose the zero restrictions on the structural model in matrix A or equivalent A^{-1} to be lower triangular such that the coefficient $\hat{a}_{12}, \hat{a}_{13}, \hat{a}_{23}$ is equal to zero. Thus, this restriction results in an identified system since we have six unknown parameters $(\hat{a}_{11}, \hat{a}_{21}, \hat{a}_{22}, \hat{a}_{31}, \hat{a}_{32}, \hat{a}_{33})$ which can be estimated into six equations. We can rewrite equation (9) in matrix form after imposing the additional restriction on the system as:

$$\begin{bmatrix} \Delta \mathrm{prod}_t \\ \mathrm{rea}_t \\ \mathrm{rpo}_t \end{bmatrix} = \begin{bmatrix} \hat{c}_{11} & \hat{c}_{12} & \hat{c}_{13} \\ \hat{c}_{21} & \hat{c}_{22} & \hat{c}_{23} \\ \hat{c}_{31} & \hat{c}_{32} & \hat{c}_{33} \end{bmatrix} \begin{bmatrix} \Delta \mathrm{prod}_{t-p} \\ \mathrm{rea}_{t-p} \\ \mathrm{rpo}_{t-p} \end{bmatrix} + \begin{bmatrix} \hat{a}_{11} & 0 & 0 \\ \hat{a}_{21} & \hat{a}_{22} & 0 \\ \hat{a}_{31} & \hat{a}_{32} & \hat{a}_{33} \end{bmatrix} \begin{bmatrix} u_t^{\text{oil-supply shock}} \\ u_t^{\text{aggregate demand shock}} \\ u_t^{\text{oil-specific demand shock}} \end{bmatrix} \tag{28}$$

The vector of variables in this thesis is $\mathrm{X}_t = [\Delta \mathrm{prod}_t, \mathrm{rea}_t, \mathrm{rpo}_t]'$, where $\Delta \mathrm{prod}$ denotes the percentage change in world crude oil production, rea_t is the real economic activity index and rpo_t refers to real oil prices. Matrix A^{-1} is the matrix in which we imposed the additional restrictions on all elements above the principal diagonal to be zero. The number of lag (p) chosen in this thesis is six for all VAR[3]. The vector of structural shocks is denoted as:

$$\mathrm{U}_t = \left[u_t^{\text{oil-supply shock}}, u_t^{\text{aggregate demand shock}}, u_t^{\text{oil-specific demand shock}}\right]' \tag{29}$$

To identify structural shocks, we focus on the term $e_t = A^{-1}u_t$ as the reduced-form shock (e_t) can be decomposed into structural shocks (u_t) as follows:

[3] We choose lag length at six because it can give more accurate results for testing oil price shocks on stock market returns. Moreover, there are other studies which have chosen this same lag length (see Park & Ratti 2008; Wang et al. 2013).

$$\begin{bmatrix} e_t^{\Delta prod} \\ e_t^{rea} \\ e_t^{rpo} \end{bmatrix} = \begin{bmatrix} \hat{a}_{11} & 0 & 0 \\ \hat{a}_{21} & \hat{a}_{22} & 0 \\ \hat{a}_{31} & \hat{a}_{32} & \hat{a}_{33} \end{bmatrix} \begin{bmatrix} u_t^{oil-supply\ shock} \\ u_t^{aggregate\ demand\ shock} \\ u_t^{oil-specific\ demand\ shock} \end{bmatrix} \tag{30}$$

Each line of equation (30) can be viewed as an equation by multiplying each term on the right-hand side. Thus, we can derive each reduced-form shock equation which is a weighted average of structural innovation. The coefficient, $\hat{a}_{11}, \hat{a}_{21}, \hat{a}_{22}, \hat{a}_{31}, \hat{a}_{32}, \hat{a}_{33}$, presents the weight to the structural shocks.

$$e_t^{\Delta prod} = \hat{a}_{11} u_t^{\Delta prod} \tag{31}$$

$$e_t^{rea} = \hat{a}_{21} u_t^{\Delta prod} + \hat{a}_{22} u_t^{rea} \tag{32}$$

$$e_t^{rpo} = \hat{a}_{31} u_t^{\Delta prod} + \hat{a}_{32} u_t^{rea} + \hat{a}_{33} u_t^{rpo} \tag{33}$$

Since we know the residual or reduced-form shocks (e_t) from predicting residuals using each equation in the VAR model, and we identify the value of A^{-1} using Cholesky decomposition methodology, we can determine the structural innovations (u_t) following equation $u_t = Ae_t$ or equation (11).

3.1.3. Implications of restrictions

We attribute fluctuation in real oil price into three structural shocks, presented as $u_t = [u_t^{oil-supply\ shock}, u_t^{aggregate\ demand\ shock}, u_t^{oil-specific\ demand\ shock}]'$. First, $u_t^{oil-supply\ shock}$ denotes unpredictable shocks to the current availability of global oil production ("oil supply shock"), $u_t^{aggregate\ demand\ shock}$ captures shocks to the global real economic activity which affects all industrial commodities ("aggregate demand shock)" and $u_t^{oil-specific\ demand\ shock}$ captures the shock in precautionary demand for crude oil due to uncertainty about future oil supply or presents change in oil demand which contrasts with change in demand for all industrial commodities; it captures shock which cannot be explained by both shocks above ("oil-specific demand shock").

The Cholesky decomposition that we impose on matrix A^{-1} in equation (27) is based on three assumptions. First, global oil supply does not respond to oil aggregate demand shocks ($u_t^{aggregate\ demand\ shock}$) and oil market specific demand ($u_t^{oil-specific\ demand\ shock}$) shocks within the same month. It is only driven by exogenous supply shocks themselves ($\hat{a}_{12} = \hat{a}_{13} = 0$). This assumption is reasonable because changing oil production is costly for oil-producing countries and it takes a long time to detect change in demand in the oil market. Thus, oil-producing countries will be slow to respond to oil demand shocks.

Second, real economic activity associated with crude oil demand is only affected by aggregate demand shocks ($u_t^{aggregate\ demand\ shock}$) and changes in crude oil production ($u_t^{oil-supply\ shock}$) occur within the same month; however, global real economic activity does not react to the oil specific market ($u_t^{oil-specific\ demand\ shock}$) in the short-term ($\hat{a}_{23} = 0$). This restriction is consistent with the fact that if demand for crude oil decreases or oil supply is disrupted, oil-producing firms are able to adjust the level of oil production immediately. Moreover, Kilian (2009) supports that global real economic activity is characterised by sluggish behaviour after oil price changes.

Finally, oil-specific demand shock ($u_t^{oil-specific\ demand\ shock}$) is the oil price shock which cannot be explained by oil supply shocks and oil aggregate demand shocks. This shock reflects the fluctuation in oil precautionary demand driven by uncertainty in future oil supply. Kilian (2009) supports that this oil-market specific demand shock also captures the exogenous shift in precautionary demand because the timing of this shock is consistent with the event, such as the uncertainty of future oil supply shortfalls due to the Persian Gulf War event. Further, oil price change driven by oil-specific demand shocks is highly correlated with the measure of precautionary demand shocks (Alquist & Kilian 2010). This oil price variable is the variable which responds to oil supply shocks, oil demand shocks and oil-specific demand shocks instantaneously.

As in this methodology, Kilian (2009) used global variables to proxy oil supply shocks, oil demand shocks and oil-specific demand shocks. Thus, these shocks from Kilian's (2009) approach are considered as global shocks.

3.2 Shock construction: Ready's (2018) methodology

As Ready (2018) explained, the methodology for constructing oil price shocks proposed by Kilian (2009) is not efficient for classifying oil price shocks because the demand and supply shocks identified by Kilian (2009) have low explanatory power for the variation in oil prices. The demand shock and supply shock measures capture only 4% of the total variation in oil price changes, with the remaining variation explained by precautionary demand shock. It is not reasonable to assume that the majority of total oil price changes are driven by concern about future supply shortfalls; thus, it can be concluded that there are other sources of oil price variation which Kilian's (2009) model does not identify.

Moreover, Kilian (2009) used dry cargo single voyage ocean freight rates as a proxy for global real economic activity which drives the demand for all industrial commodities in the global market. However, there is no statistically measurable relationship between the index of dry cargo single voyage ocean freight rates and oil demand (Kaufman 2011). For this reason, there is a question about whether dry cargo single voyage ocean freight rates can represent the global economic activity or oil demand. Further, if changes in oil demand are not reflected in the freight rates, oil price shocks will not be identified.

Another weakness of Kilian's (2009) methodology is that the measure of oil prices in the model uses the refiner acquisition cost of imported crude oil. Since this oil price includes transportation costs as part of the refiner's acquisition cost, the oil price is positively correlated with transportation costs. Thus, this confounds the relationship between oil supply and oil price because the transaction cost or tariff which is included in the oil price does not accrue to oil producers.

Due to the reasons mentioned above, Ready (2018) proposed a new methodology for constructing oil price shocks. This methodology classifies the shocks into three types of shocks: supply shocks, demand shocks and risk shocks. The important assumptions in this model are that oil production is assumed to be a depletable natural resource and there is difficulty in changing production levels. The two possible ways of increasing oil prices are a rise in the level of oil demand and a reduction in the level of oil supply. The assumption behind this methodology is that oil producing firms are not affected by oil price variations because if oil price rises due to increasing oil demand, an increase in price leads to higher volume of sales, a rise in oil production and higher revenue for oil producers. On the other hand, if oil prices increase because of an oil supply shortfall, the impact of this situation is inconclusive since oil producing firms will sell the lower amount of oil, but they still benefit from selling at higher prices. Thus, oil producing firms have a natural hedge against oil supply shocks. Because returns of oil producers are assumed to be unaffected by shock to oil production, Ready (2018) uses oil producer stock return as the control variable to identify the shocks of oil price changes.

In addition, this model allows for shocks in the expected rate of return on oil-producing value. This shock is driven by changes in attitude toward risk. If the attitude towards risk increases, oil producing firms become riskier and the value of oil producing firms decreases as the discount rate increases. Although risk shocks affect the return of oil producing firms, there is a relatively small impact on oil prices. Thus, risk shocks or discount rate shocks are the control factor to classify demand and supply shocks.

Following this assumption, Ready (2018) introduces methodology to decompose changes in oil prices into three different shocks (supply shocks, demand shocks and risk shocks) using the following steps. First, we identify risk shocks or the unexpected changes in the volatility index (VIX) index by running the ARMA (1,1) model on the VIX index. The residuals from this process are defined as innovation to the VIX ($\varepsilon_{VIX,t}$), which is the proxy for changes in market discount rates driven by changing attitudes toward risk. Then, we run the OLS regression for the following model:

$$R_t^{Prod} = \alpha + \beta_{VIX}\varepsilon_{VIX,t} + d_t, \tag{34}$$

where R_t^{Prod} is the index of oil producer return, $\varepsilon_{VIX,t}$ is the innovation of VIX index which is the residuals of the ARMA (1,1) process and d_t denotes the residual of this model which is the demand shock. Demand shocks are shocks to the oil producer index which are unrelated to innovation of the VIX index.

The rationale behind equation (34) is that the return of oil producers is affected by the level of oil demand and the innovation of VIX, which is the proxy for market discount rate. However, Kogan et al. (2009) suggested that oil prices (p) be given by equation (35);

$$p = A_t(O_t)^{\frac{-1}{\alpha}} \tag{35}$$

where A_t denotes the aggregate level of oil demand, O_t is the total production of oil and α is the elasticity of oil demand. From this equation, it appears that there are two possible channels causing oil price changes: the level of oil demand and the level of oil supply. Nevertheless, equation (34) shows that oil supply has no impact on the return of oil producers. This is because the model assumes that oil supply is a depletable resource. If oil well production decreases, oil producers will increase the use of oil flow input to offset decreases in oil production. This can prevent increases in profitability for oil producers. Thus, oil producer returns do not respond to changes in oil production. On the other hand, if the level of oil demand increases, this leads to a rise in oil prices and oil production corresponding with an increase in the value of oil producing firms. Moreover, the VIX index is a proxy of discount rate which affects oil producers' returns. If the discount rate decreases, the profit of oil-producing firms will increase. Based on this, oil producer returns are dependent upon only the discount rate, which is innovation of the VIX index and demand shocks.

However, the model can suffer from misspecification because of omitted variables which also affect oil producer returns. For simplicity, we assume that there are no other relevant variables that impact on the value of oil producing firms or that other relevant variables contain a zero-beta, which indicates that these variables are uncorrelated with the market.[4]

Further, we identify oil supply shocks as the portion of change in oil prices that is orthogonal to demand shocks and innovation to VIX. Ready (2018) carried out this identification by running the following model to identify supply shock:

$$\Delta \mathrm{p_t} = \alpha + \beta_{\mathrm{d}} \mathrm{d_t} + \beta_{\mathrm{VIX}} \varepsilon_{\mathrm{VIX,t}} + s_t \,, \tag{36}$$

where $\Delta \mathrm{p_t}$ denotes the oil price changes, $\mathrm{d_t}$ is the constructed residual from

[4] We also tested for model misspecification which can be caused by omitted variables in equation (34). The test is conducted using Ramsy's (1969) regression specification error test (RESET) test. We failed to reject the null hypothesis, which indicates that the model is correctly specified at the 5% significance level (p-value = 0.6563). This suggests that this functional form is correct.

equation (34) or demand shock, $\varepsilon_{VIX,t}$ is the innovation of VIX index and the residual of this regression denoted as s_t is basically the supply shock. By construction of equation (36), the demand shock, supply shock and innovation to VIX are normalised to be constrained to the sum up of the total oil price change.

3.3 Baseline regression

3.3.1. Regression for the impact of oil price shocks on stock market returns

After construction of the structural shocks from oil prices and classification of them as demand and supply shocks, we first addressed the question of how stock market returns respond to changes in oil prices due to local supply, demand and risk shocks. We followed the approach of Ready (2018) and Jones et al. (1996) who built the OLS regression model to measure the impact of oil price shocks on stock market returns.

$$R_t^{Mkt} = \alpha + \beta_d d_t + \beta_s s_t + \beta_{VIX} \varepsilon_{VIX,t} + v_t \tag{37}$$

In the representative model above, the dependent variables are the stock market returns of major oil-importing and exporting countries in our sample. The variables are in logarithmic form and denoted by "R_t^{Mkt}". On the other hand, the explanatory variables are demand shocks (d_t), supply shocks (s_t) and innovation to VIX ($\varepsilon_{VIX,t}$), which are constructed in Section 3.2. We use innovation to VIX ($\varepsilon_{VIX,t}$) instead of risk shocks (v_t) because innovation to VIX has more explanatory power for economic magnitude than risk shocks, which is a constant multiple of innovation to VIX (Ready, 2018).

We construct global oil price shocks using Kilian's (2009) approach and compare the results with Ready's (2018) methodology in order to analyse whether local shocks and global shocks have different effects on stock market returns.

We run the same regression model as in equation (37) using OLS to analyse the relationship between oil price shocks and stock market returns in each country; however, the shocks are constructed in a different manner. We use demand shock ($\mathrm{u}_{\mathrm{t}}^{\text{aggregate demand shock}}$) and supply shock ($\mathrm{u}_{\mathrm{t}}^{\text{oil−supply shock}}$), constructed as described in Section 3.1, and oil-specific demand shock ($\mathrm{u}_{\mathrm{t}}^{\text{oil−specific demand shock}}$) is used in place of innovation to VIX. We can rewrite the equation as follows:

$$R_t^{Mkt} = \alpha + \beta_d \mathrm{u}_{\mathrm{t}}^{\text{demand shock}} + \beta_s \mathrm{u}_{\mathrm{t}}^{\text{supply shock}} + \beta_{specific} \mathrm{u}_{\mathrm{t}}^{\text{specific demand shock}} + v_t \quad (38)$$

In conducting the OLS regression in equations (37) and (38), the possible presence of both heteroskedasticity and autocorrelation of the error term is dealt with using The Newey and West (1987) variance-covariance estimator.

Then, we measure the response of stock market returns to local and global oil price shocks based on the following regression:

$$R_t^{Mkt} = \sum_{n=1}^{N} \alpha_i R_{t-1}^{Mkt} + \sum_{n=1}^{N} \rho_i \gamma_{t-n} + v_t \quad (39)$$

$$R_t^{Mkt} = \sum_{n=1}^{N} \theta_i R_{t-1}^{Mkt} + \sum_{n=1}^{N} \delta_i u_{t-n} + v_t \quad (40)$$

where R_t^{Mkt} is the stock market returns of each country, γ_{t-n} presents either the identified local oil supply or local oil demand shock which was constructed in Section 3.2, u_{t-n} is either the identified global oil supply or the global oil demand shock estimated in Section 3.1. In equation (39) and (40), the impulse response coefficients correspond to ρ_i and δ_i, respectively.

3.3.2. Regression for the impact of oil price shocks on exchange rates

The second purpose of this thesis is to identify differences in the impact of local oil price shocks and global oil price shocks on exchange rates. First, we investigate the impact of oil price shocks on the exchange rate of each country estimated based on the OLS regression model of Su et al. (2016). We run these two regressions below for local oil shocks (equation (41)) and global oil shocks (equation (42)) separately.

$$x_{it} = \alpha + \beta_d d_t + \beta_s s_t + \beta_{VIX} \varepsilon_{VIX,t} + v_{it} \tag{41}$$

$$x_{it} = \alpha + \beta_d \mathrm{u}_{\mathrm{t}}^{\text{demand shock}} + \beta_s \mathrm{u}_{\mathrm{t}}^{\text{supply shock}} + \beta_{specific} \mathrm{u}_{\mathrm{t}}^{\text{specific demand shock}} + v_{it} \tag{42}$$

Where x_{it} is the exchange rate of return for each country, d_t, s_t and $\varepsilon_{VIX,t}$ are the identified local oil demand, supply and risk shocks, respectively, which are constructed from Section 3.2, $\mathrm{u}_{\mathrm{t}}^{\text{demand shock}}$, $\mathrm{u}_{\mathrm{t}}^{\text{supply shock}}$ and $\mathrm{u}_{\mathrm{t}}^{\text{specific demand shock}}$ are the identified global oil demand, supply and oil-specific demand shock from Section 3.1. The coefficient estimated by OLS captures how movement in exchange rates corresponds to oil price shocks. This regression does not include lags of oil price shocks as explanatory variables because if oil price shock occurs, exchange rates can capture new information concurrently as exchange rate markets are efficient (Basher et al. 2016; Su et al. 2016).

Next, we examine the overall impact on oil-exporting and oil-importing countries following the baseline regression of Habib et al. (2016). For this section, we estimate the pooled panel model on quarterly data. The baseline regression is expressed as[5]:

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[5] This regression model has a weakness of pooled panel OLS regression as the presence of a lagged dependent variable among the independent variable. Since x_{it} is a function of v_{it}, it follows that $x_{i,t-1}$ is also a function of v_{it}. Thus, the independent variable $x_{i,t-1}$ is correlated with the error term (v_{it}). This causes the OLS estimator to be biased and inconsistent (Baltagi 2005).

$$x_{it} = k_i + \lambda_t + \beta x_{i,t-1} + \gamma y_{i,t-1} + \delta u_t y_{i,t-1} D_{it} + \varepsilon D_{it}^{crisis} + \eta D_{it} + \nu_{it} \quad (43)$$

where x_{it} is the variables of interest including the natural logarithm of the bilateral local exchange rate against the U.S. dollar and the real effective exchange rate, y_i denotes the oil trade balance to GDP, u_t is the vector of identified oil price shocks denoted as either equation (44) or equation (45), which is constructed on a monthly basis from Section 3.1 and 3.2, respectively, and then aggregated to a quarterly basis. D_{it}^{crisis} is the dummy variable which is equal to 1 if depreciation of the bilateral nominal exchange rate is greater than 25%, at least twice the rate of depreciation compared to the previous year and the depreciation of the previous year is less than 40% (Milesi-Ferretti & Razin 2000). Otherwise, this dummy variable is equal to zero. We also account for the potential differences between the reactions of oil-exporting countries and oil-importing countries by including another dummy variable (D_{it}) which equals to 1 if the country is an oil-exporter, and zero otherwise. In addition, we include time and country fixed effects in the regression.

$$u_t = \begin{bmatrix} \mathrm{u}_t^{\text{supply shock}} \\ \mathrm{u}_t^{\text{demand shock}} \\ \mathrm{u}_t^{\text{specific demand shock}} \end{bmatrix} \quad (44)$$

$$u_t = \begin{bmatrix} \mathrm{u}_t^{\text{supply shock}} \\ \mathrm{u}_t^{\text{demand shock}} \\ \mathrm{u}_t^{\text{risk shock}} \end{bmatrix} \quad (45)$$

Interestingly, the coefficient $\delta = [\delta_1, \delta_2, \delta_3]$ is an important aspect and can be interpreted as the economic magnitude, suggesting an interaction term between the three different identified oil price shocks and the country's structural characteristic, which is its oil trade balance. This measures change in x_{it} which is brought about by changes in identified oil shocks in oil exporter and oil importer countries.

CHAPTER 4
Data description

4.1. Countries in the sample

Our sample comprises major oil importing and exporting countries in order to examine the effect of oil prices changes on the stock markets and exchange rates. Our data includes nine oil-importing countries: U.S., India, Japan, Korea, U.K., France, Germany, Italy and China, and six oil-exporting countries: Canada, Mexico, Norway, Kuwait, Saudi Arabia and Russia.

Table 1 presents information about the net oil import and net oil export for oil-importing and oil-exporting countries in our sample, respectively. It also shows the share of each country in global oil consumption. China, the U.S. and Japan were the three largest world oil importers in 2016. China has had the greatest increase in crude oil consumption, which grew by approximately 439% from 1990-2016.[6] China's oil consumption accounts for 12.8% of the total global oil consumption after the U.S. which accounts for 20.3%. In addition, Saudi Arabia, Russia and Canada are the three largest oil exporters, whereas these countries consume much less oil than the top oil-importers. Interestingly, the largest shares of oil demand come from Asian countries (China, Japan, India, Korea), reflecting rapid economic growth; however, the U.S. still has the greatest oil consumption globally. Moreover, Kuwait and Saudi Arabia have the highest oil export to GDP ratios, approximately 27% and 21% of GDP, respectively; crude oil is the top export of Kuwait, representing 64.4% of their exports, while the export of crude oil accounts for half of Saudi Arabia's total export (55.2%).

[6] This growth rate is based on statistics from the BP Statistical Review of World Energy (2017).

Table 1: Net oil import (export), oil consumption and the percentage of oil import (export) to Gross Domestic Product (GDP)

This table shows the net oil import for oil-importing countries and the net oil export for oil exporting countries in 2016. Moreover, the share of each country in global oil consumption and the annual oil import of importing countries (oil export of exporting countries) to GDP in 2016 are reported. The data is collected from the BP Statistical Review of World Energy (2017).

Country	Net import (net export) (thousands of barrels per day)	Share in world oil consumption	Oil import (export) to GDP
Oil-importing countries			
U.S.	7,277	20.30%	0.58%
India	3,633	4.60%	2.69%
Japan	4,037	4.20%	1.03%
Korea	2,763	2.90%	3.13%
U.K.	584	1.70%	0.54%
France	1,602	1.70%	0.73%
Germany	2,394	2.50%	0.83%
Italy	1,153	1.30%	1.02%
China	8,382	12.80%	0.54%
Oil-exporting countries			
Canada	2,117	2.40%	2.58%
Mexico	587	1.90%	1.48%
Norway	1,753	0.30%	6.09%
Kuwait	2,652	0.50%	27.69%
Saudi Arabia	8,443	4.00%	21.07%
Russia	8,024	3.30%	5.74%

4.2. Variables and data description

In this thesis, the data is based on monthly and quarterly data covering the period January 1990 to December 2016. To analyse the impact of oil price shocks on stock market returns, we use monthly data for the major stock index for each country to proxy stock market returns: S&P 500 (U.S.), BSE Sensex (India), NIKKEI 225

(Japan), KOSPI Composite (Korea), FTSE 100 (U.K.), CAC 40 (France), DAX 30 (Germany), FTSE MIB (Italy), Shanghai Composite (China), S&P/TSX Composite (Canada), Bolsa IPC (Mexico), OSLO Stock Exchange All Share Index (Norway), Kuwait Stock Exchange Index (Kuwait), Tadawul All Share (Saudi Arabia) and MICEX (Russia). These data are collected from Datastream, except that the Kuwait stock market index is taken from Bloomberg.

In the second part of this thesis, we analyse the impact of oil price shocks on exchange rates. For this portion of the analysis, we use both monthly and quarterly data for the following variables: bilateral nominal exchange rates expressed as local currency per U.S. dollar, collected from IMF International Financial Statistics (IMF IFS) and real effective exchange rate (REER) data from Darvas (2012). We construct the log of exchange rate returns using the formula:

$$r_t = 100 * \ln\left(\frac{p_t}{p_{t-1}}\right), \tag{46}$$

where p_t is either the bilateral exchange rate against USD or the REER at time *t*. After calculation, we obtain r_t which denotes the bilateral exchange rate returns and real effective exchange rate returns, respectively. An increase (decrease) in exchange rate implies an appreciation (depreciation) of the U.S. dollar.

Table 2 (panel A) shows the summary statistics for the market return of each country. The distributions of the stock market returns are negatively skewed. This is consistent with previous studies which report that stock market returns tend to be negatively skewed rather than symmetrical because the asymmetry of stock correlations is higher when the market is in downtrend (see Albuquerque et al. 2012; Blanchard & Watson 1982; French, Schwert & Stambaugh 1987).

Table 2: Descriptive statistics for stock market returns and exchange rates

Panel A shows the summary statistics of the main index of stock market returns for each country. The index returns are expressed as natural logarithms. Panel B shows the bilateral nominal exchange rate against the U.S. dollar (USD) and the real effective exchange rate for each country in the sample. All data are based on monthly measurements.

Panel A: Summary statistics of stock market returns

Variables	Mean	Standard deviation	Skewness	Kurtosis	Median
Market return in oil-importing countries					
U.S.	0.006	0.042	-0.779	4.762	0.010
India	0.011	0.082	0.331	4.987	0.011
Japan	-0.002	0.063	-0.166	3.38	0.001
Korea	0.002	0.077	0.237	6.198	0.003
U.K.	0.003	0.043	-0.379	4.387	0.007
France	0.003	0.060	-0.611	4.594	0.009
Germany	0.006	0.062	-0.897	5.593	0.013
China	0.010	0.124	1.850	15.916	0.006
Italy	-0.002	0.066	-0.459	4.106	0.007
Market return in oil-exporting countries					
Canada	0.004	0.042	-1.183	7.207	0.009
Mexico	0.014	0.073	-0.308	4.408	0.017
Norway	0.007	0.063	-0.986	5.514	0.014
Kuwait	0.005	0.052	-0.092	7.875	0.000
Saudi Arabia	0.007	0.075	-0.688	4.480	0.012
Russia	0.013	0.120	-0.902	7.844	0.016

Panel B: Summary statistics of exchange rates

Variables	Mean	Standard deviation	Skewness	Kurtosis	Median
Bilateral nominal exchange rate in oil-importing countries					
India	0.428	1.990	3.290	30.14	0.081
Japan	-0.066	2.646	-0.289	4.030	-0.006
Korea	0.172	3.162	5.624	66.140	0.062
U.K.	0.076	2.337	0.845	5.773	-0.037
France	0.014	2.430	0.113	3.219	-0.009
Germany	0.021	2.461	0.086	3.267	-0.021
China	0.156	2.429	14.59	237.0	-0.002
Italy	0.108	2.511	0.383	3.961	-0.041
Bilateral nominal exchange rate in oil-exporting countries					
Canada	0.043	1.694	0.411	7.963	0.028
Mexico	0.629	3.290	4.706	43.79	0.273

Variables	Mean	Standard deviation	Skewness	Kurtosis	Median
Norway	0.076	2.557	0.483	4.572	0.122
Kuwait	0.012	0.563	1.212	10.370	0.295
Saudi Arabia	-0.001	0.034	2.920	67.36	0.001
Russia	2.077	7.165	5.145	45.10	0.471
Real exchange rate return in oil-importing countries					
U.S.	0.068	1.406	0.277	4.646	0.076
India	0.028	2.055	-2.313	23.50	0.105
Japan	-0.059	2.518	0.540	4.838	-0.245
Korea	-0.023	2.847	-5.549	66.20	0.202
U.K.	-0.022	1.644	-1.072	6.915	0.002
France	-0.031	0.756	-0.027	3.271	0.007
Germany	-0.016	0.899	0.230	3.987	-0.026
China	0.045	2.451	-8.791	120.4	0.211
Italy	-0.042	1.188	-1.973	17.770	0.068
Real exchange rate return in oil-exporting countries					
Canada	-0.063	1.510	-0.380	6.873	-0.123
Mexico	-0.047	3.179	-3.434	33.66	0.304
Norway	-0.021	1.333	-0.487	4.897	0.018
Kuwait	0.143	1.316	0.085	3.625	0.169
Saudi Arabia	0.061	1.465	0.136	4.330	0.023
Russia	0.542	5.875	-0.921	22.84	0.772

The average monthly returns for all countries are smaller than their standard deviation. Mexico had the highest average market return (0.014%) among the 15 countries in our data, while Japan and Italy had the lowest average market returns; these are the only two countries that had negative average returns (-0.002%). Panel B presents the descriptive statistics of the exchange rates. The Russian ruble had the largest amount of volatility in terms of both the bilateral exchange rate against the USD and the real exchange rate, while the currency of Saudi Arabia had the least volatility as Saudi Arabia has a fixed exchange rate regime to the U.S. dollar.

Moreover, we use oil trade balance as the key variable in the baseline regression. Oil trade balance data is taken from the Global Energy Statistics. Table 3 shows the percentage of oil trade balance, which is the difference between oil export and oil import in each country, to GDP ratio. The oil trade balance of oil-exporting countries appears as a positive value. In line with Table 1, Korea and Saudi Arabia had the world's largest crude oil import and export to GDP ratio, respectively. Among oil-exporting countries, there were four countries (Saudi Arabia, Kuwait, Norway, Russia) with oil trade balance to GDP larger than 10%.

Table 3: The average oil trade balance to GDP (%) of each country over the period 1990-2016

This table shows the average oil trade balance as a share of GDP for each country over the period 1990-2016. The oil trade balance is the difference between oil exports and oil imports, collected from the Global Energy Statistics. The oil trade balance and GDP are in billion USD.

Country	Oil trade balance to GDP (%)
Oil-exporting countries	
Saudi Arabia	39.02
Kuwait	13.27
Norway	12.06
Russia	10.76
Canada	2.88
Mexico	1.39
Oil-importing countries	
U.K.	-0.03
Italy	-0.38
U.S.	-1.24
China	-1.24
Japan	-2.23
France	-3.68
Germany	-3.81
India	-3.91
Korea	-4.90

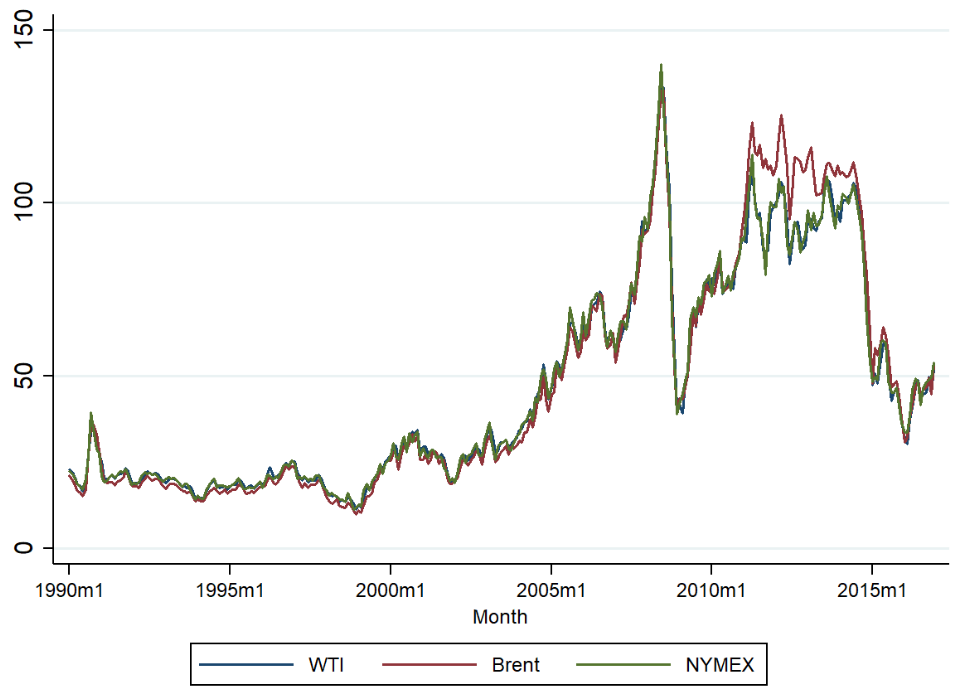
4.3. Data for shock construction using Ready's (2018) approach

As oil price changes driven by demand shocks and supply shocks have a different impact on stock market returns, we need to identify the sources which cause oil price changes. We decompose changes in oil prices into three different shocks: demand shocks, supply shocks and risk shocks. To proxy all shocks, we use the following variables to construct these shocks. First, we define the World Integrated Oil and Gas Producer Index to proxy the index of oil producer returns. While we construct local oil price shocks from this approach, Ready (2018) used global oil producing returns as control variables to identify oil price changes from local supply and local demand shocks as oil producers have a natural hedge against oil shocks, thus, oil-producing returns are unresponsive to these oil shocks. These data are available from Datastream. Next, the changes in oil prices are defined using three different oil prices: the log of returns on the second nearest NYMEX crude oil – Light Sweet Oil contract, West Texas Intermediate (WTI) crude oil and Brent crude oil. In line with Ready (2018), we use NYMEX future prices to proxy oil price changes for the U.S. market, while Brent crude oil is used for Italy, the U.K., France and Germany as it is a dominant oil price benchmark in the European market. We use WTI crude oil for the rest of the countries in our sample. These oil price data are taken from the U.S. Energy Information Administration (EIA).

Figure 1 plots the WTI, Brent crude oil price and NYMEX over the sample period. The NYMEX futures price tends to be highly correlated with the other two major prices of crude oil, WTI and Brent. The correlation between NYMEX and WTI is 0.997 while the correlation between NYMEX and Brent is 0.988. All oil prices track closely to each other until the beginning of 2011. WTI crude oil has a downward pressure from the transportation bottlenecks issue in the U.S. Moreover, Arab Spring causing a supply shortfall and strong oil demand in the Asian market causes upward pressure on Brent crude oil prices over WTI before the WTI-Brent price spread becomes narrow again in 2014.

Figure 1: WTI, Brent and NYMEX crude oil prices over the period 1990-2016

The graph shows the oil price of WTI, Brent and the second nearest maturity NYMEX–Light Sweet Oil contract during the period 1990-2016. All data are in monthly frequency.



For a proxy for changes in discount rates, we use innovation to the VIX captured by the residual of the log of the VIX index estimated from the ARMA(1,1) model, because the VIX index is a good proxy for the aggregate degree of risk-aversion in the market (Bollerslev et al. 2009). We use the VIX index for each country: CBOE S&P500 VIX (U.S.), India NSE VIX (India), NIKKEI VIX (Japan), KOSPI 200 VIX (Korea), FTSE 100 VIX (UK), CAC 40 VIX (France), Deutsche Börse VDAX (Germany), Italy MIB VIX (Italy), AlphaShares Chinese VIX (China), S&P/TSX 60 VIX (Canada), Volatility Index Mexico (Mexico), Norwegian Volatility Index

(Norway), Kuwait Stock Price Volatility Index (Kuwait), Saudi Arabia Stock Price Volatility Index (Saudi Arabia) and Russian VIX (Russia)[7]. All data are taken from Bloomberg, except for Kuwait and Saudi Arabia, which are collected from the Federal Reserve Bank of St. Louis. Since this volatility index data in each country has limited available historical data, the main period of data applied in this thesis covers a different time horizon depending on the VIX data in each country. The sample period for each country is given in Table 4.

4.4. Data for shock construction using Kilian's (2009) approach

For another shock construction methodology, we use Kilian's (2009) methodology for constructing oil price shocks into three shocks: supply shocks, demand shocks and precautionary demand shocks.

To proxy the oil price changes, following Kilian (2009) and Kilian and Park (2009), we employ U.S. refiners' acquisition cost for imported crude oil reported by the Energy Information Administration (EIA), then deflated by the U.S. consumer price index (CPI) to obtain the real oil prices. The U.S. consumer price index is obtained from the Federal Reserve Bank of Saint Louis. We can use real oil prices based on the U.S. market as a proxy for global real oil prices because the U.S. refiners' acquisition cost of imported crude oil has a high correlation with WTI and Brent crude oil prices, which are the two important crude oil benchmarks in the world.[8]

With a different approach to construct oil price shocks, we define global real economic activity as the proxy of oil demand. The indicator of real economic activity, constructed by Kilian (2009), is based on the dry cargo single voyage freight rate, and

[7] See Appendix C for the calculation methodology for the volatility (VIX) index for each country in our sample.

[8] The correlation between U.S. refiners' acquisition cost of imported crude oil and WTI is 0.993 and the correlation between U.S. refiners' acquisition cost of imported crude oil and Brent crude oil is 0.997.

this index can capture the activity which drives the industrial commodity demand in the global market. The dry cargo shipping rate index reflects the global business cycle or fluctuation in oil consumption demand in all industrial commodities. Supported by Klovland (2004), the demand for shipping services is driven by the global economic activity; thus, the shipping index can be a good measure for oil consumption demand as oil is an input in most global economic activities. Kilian (2009) constructs this index from the equal-weighted average of the percent growth shipping rates, which is then deflated by the U.S. CPI to obtain the real global economic activity. These data are collected from Kilian's website[9]. Most of the previous research uses this index to proxy the oil demand for global industrial commodities (see Fang & You 2014; Jung & Park 2011; Kilian & Park 2009; Raghavan 2015). On the other hand, we use the measure of world crude oil production collected from the Energy Information Administration to proxy the oil supply (Kilian 2009).

Table 4 also displays the descriptive statistics of the data sample used to construct the local and global oil price shocks. The sample mean, standard deviation, skewness, kurtosis and median are presented. Panel A shows the variables in Ready's (2018) methodology. The VIX index, oil producer index returns and stock market returns are shown as natural logarithms. The statistics for NYMEX, WTI and Brent crude oil prices are similar, which is consistent with Figure 1. The VIX index of all countries is positively skewed. Panel B shows the variables in Kilian's (2009) approach including the real economic activity index, change in oil production and real oil prices. Oil production and real oil prices are expressed as natural logarithms. We observed that the global economic activity had the highest volatility.

[9] We obtained this index data from the website: http://www-personal.umich.edu/~lkilian/

Table 4: Descriptive statistics for data used in shock construction

This table shows the summary statistics of the variables used to construct the oil price shocks. Panel A shows the variables used in Ready's (2018) methodology. The VIX index is the natural logarithm of the volatility index. Oil producer return is the natural logarithm of the World Integrated Oil and Gas Producer Index. Oil price changes are measured using one month returns on the second nearest maturity NYMEX crude oil – Light Sweet Oil Contract, WTI crude oil and Brent crude oil. Panel B shows the variables used in Kilian's (2009) methodology. The real economic activity index is a proxy for global oil demand. The oil price is measured using the U.S. refiners' acquisition cost for imported crude oil deflated by CPI. Change in oil price and oil production are expressed by a change in the natural logarithm of the variables. All data are in monthly frequency.

Panel A: Variables used in Ready's (2018) shock construction

Variables	Mean	Standard deviation	Skewness	Kurtosis	Median	Period
Oil producer index returns	0.005	0.055	-0.301	3.92	0.005	
Change in oil prices						
NYMEX	0.133	6.587	-1.130	6.969	0.815	
WTI oil prices	0.134	6.125	-1.048	5.522	0.895	
Brent oil prices	0.149	6.251	-1.045	5.025	0.920	
VIX index in oil-importing countries						
U.S.	2.919	0.337	0.589	3.025	2.872	1990-2016
India	3.088	0.359	0.778	3.108	3.029	2007-2016
Japan	3.169	0.296	0.511	4.149	3.168	1990-2016
Korea	2.975	0.317	0.329	3.041	2.974	2003-2016
U.K.	2.928	0.376	0.739	3.511	2.873	2000-2016
France	3.101	0.344	0.552	3.387	3.089	2000-2016
Germany	3.072	0.362	0.602	3.180	3.032	1992-2016
China	3.192	0.351	0.877	3.996	3.129	1999-2016
Italy	3.162	0.319	0.496	3.132	3.149	1999-2016
VIX Index in oil-exporting countries						
Canada	2.908	0.311	0.797	4.607	2.909	2002-2016
Mexico	2.992	0.340	1.059	4.256	2.920	2004-2016
Norway	3.072	0.362	0.602	3.180	3.032	1992-2016
Kuwait	2.944	0.355	0.688	3.251	2.898	2000-2016
Saudi Arabia	2.961	0.350	0.567	3.128	2.939	2006-2016
Russia	3.520	0.383	1.445	6.334	3.485	1997-2016

Panel B: Variables used in Kilian's (2009) shock construction

Variables	Mean	Standard deviation	Skewness	Kurtosis	Median	Period
Real economic activity	1.374	28.43	-0.157	4.479	-2.228	1990-2016
Real imported crude oil prices	2.934	0.547	0.276	1.965	2.797	1990-2016
Changes in oil production	0.001	0.009	-0.689	9.939	0.001	1990-2016

CHAPTER 5
Empirical results

5.1 Unit root test

Before running the structural VAR model, we need to test for the unit root property since implementing SVAR when data is non-stationary could lead to a spurious regression problem, resulting in unreliable results. The stationary of variables is tested by the Augmented Dicky Fuller (ADF) and Phillips–Perron (PP) tests.

Table 5 shows the results of the stationary testing by the ADF and PP for each variable included in the SVAR model: oil price changes, real economic activity index, changes in oil production and stock market return of each country. The null hypothesis is that the variables contain a unit root or non-stationary. As seen in Table 5, we can reject the null hypothesis for both the ADF and PP test with trend and without trend at 1% significance level for all variables except for the real economic activity index. However, the data for the real economic activity index is already detrended as the trend can reflect advances in the technology of shipping. Kilian (2009), who proposed this index, already removed the trend to make this index more appropriate; thus, we do not consider calculating first different for this data. The results for the other variables suggest that all variables are stationary or have no unit root property.

5.2 Evolution of historical oil price shocks

This section illustrates the value of structural shocks after constructing local oil price shocks using Ready's (2018) methodology from Section 3.2 and global oil price shocks using Kilian's (2009) methodology from Section 3.1. Figure 2 plots the evolution of the fluctuation in oil prices over the period of 1990–2016. This graph presents the causes of historical local oil price shocks driven by three types of shocks, supply shock, demand shock and risk shock, as determined using Ready's (2018) approach. All shocks are scaled as annual averages[10].

Table 5: Unit root tests

The unit root test results as determined by the Augmented Dicky Fuller (ADF) and Phillips–Perron (PP) test for variables: changes in oil price, real economic activity index, changes in oil production and stock market returns of each country in the sample.

	ADF test		PP	
Variables	Without trend	Trend	Without trend	Trend
Oil price changes	-10.907	-10.889	-10.538	-10.518
Real economic activity	-2.894	-2.889	-3.171	-3.166
Oil production	-20.661	-20.638	-21.074	-21.056
Market return in oil-importing countries				
U.S.	-17.095	-17.088	-17.134	-17.125
India	-15.551	-15.561	-15.498	-15.502
Japan	-16.394	-16.526	-16.407	-16.523
Korea	-15.399	-15.391	-15.300	-15.290
U.K.	-17.888	-17.881	-17.891	-17.885
France	-18.293	-18.270	-18.291	-18.268
Germany	-17.009	-16.983	-17.032	-17.006
China	-17.153	-17.223	-17.153	-17.220
Italy	-14.066	-14.057	-14.060	-14.050
Market return in oil-exporting countries				
Canada	-15.371	-15.350	-15.408	-15.386
Mexico	-16.776	-16.935	-16.766	-16.916
Norway	-15.996	-15.974	-16.078	-16.055
Kuwait	-13.552	-13.658	-13.699	-13.783
Saudi Arabia	-12.637	-12.758	-12.790	-12.880
Russia	-12.858	-12.859	-12.933	-12.927

[10] All three shocks in Section 5.2 are scaled as annual averages in order to plot the graph showing historical oil price fluctuations. However, we also plotted oil price shocks using monthly data and found a similar trend for the causes of fluctuation in oil prices. See Figure A.1 and A.2 in Appendix A.

For the purpose of comparison with global oil price shocks, we sum the local oil price shocks to compare with global oil price shocks and scale these as annual averages. In Figure 2, the evolution of historical oil shocks is similar to Figure 3 over the majority of the sample period. This figure shows that oil supply shocks have a comparatively small contribution to oil price changes while demand shocks and risk shocks are the main sources of oil price fluctuation over the sample period. The oil price drop in late 2008, during the global financial crisis, is caused by the effect of decreases in demand shocks and supply shocks. Moreover, the increase in discount rate shocks is one of the main factors in this event because attitudes towards oil price risks during the financial crisis were riskier. The decline in the global economy leads to risky expectations of the oil market, thus affecting oil price volatility. Risk shocks have a relatively small impact on oil price changes as compared to demand shocks. The collapse of oil prices in late 2008 was mainly based on demand shocks. This is supported by the findings of Kilian and Lee (2014), whereas Kilian's (2009) approach suggests that precautionary demand is the main contribution in this period. Moreover, Ready's (2018)' methodology can capture the oil supply shocks in 2014 which led to decreases in crude oil prices since the global oil production exceeded the global demand. This excess capacity of supply is the main factor, rather than demand shocks.

Figure 3 illustrates the historical global oil price shocks constructed by Kilian's (2009) methodology. Overall, the graph conforms with the results of Kilian (2009) for the period 1990-2007; however, our results are able to explain the cause of oil price changes during recent years as our sample period covered the years 1990-2016. Clearly, the first panel of Figure 3 shows that supply shocks have a relatively small contribution to oil price changes; consistent with what is shown in Figure 2. On the other hand, oil demand shocks and oil-specific demand shocks have a major contribution to the real price of oil. In 1990, oil prices increased significantly during the Gulf War and the main contributing factor for the higher oil prices was oil-specific demand shock, which reflects the fear of an oil supply shortfall. Although there was an oil supply disruption in 1990 because of the war, the main effect of this event was changes in precautionary demand. This suggests that the shift in expectation is reflected in oil prices before oil production is disrupted, as the timing of oil price changes does not coincide with the timing of actual oil production (Barsky & Kilian 2004).

The graph also shows that the oil price fell in 1997-1998 (the Asian financial crisis) due to demand shocks and oil-specific demand shocks, suggesting that the crisis slowed growth in demand of crude oil. This is also consistent with the fact that an unexpected change in the financial situation produces an unexpected change in the future oil market; thus, precautionary demands have an important role in oil price changes. However, the oil prices started to increase in year 1999 after the crude oil production response to demand whereby production levels were cut. There is clear evidence that oil producers in OPEC cooperated to cut oil production so that the oil price responded positively and rose to the normal price. This oil price increase was driven by oil supply shocks as shown in the first panel of Figure 3. Moreover, the large decrease in oil price from the global financial crisis in 2008 resulted from low demand shocks and low oil-specific demand shocks before the price recovered in 2009. Oil prices dropped sharply again in 2014 due to a fall in oil demand. This is not consistent with the fact that oil prices decrease because of excess capacity of oil supply; in particular, the graph shows that oil supply shocks play a negligible role in oil price variation.

The results of this section suggests that for Kilian's (2009) approach, a large portion of price movement during this sample period was caused by oil-specific demand shocks while Ready's (2018) approach suggests that the effect of flow demand shocks is the main contributor to oil price changes. This is consistent with the argument of Ready (2018) who suggested that Kilian's (2009) shock construction fails to capture the effects of global demand shocks and supply shocks on oil price fluctuations.

5.3. Local oil price shocks and stock market returns

Before running the OLS regression, a preliminary regression of equations (37), (38), (41) and (42) is conducted to investigate whether the residuals of the regression model exhibit autocorrelation and heteroscedasticity. We perform a test based on the Portmanteau (Q) statistic developed by Ljung and Box (1978) for autocorrelation and the Breusch–Pagan (1979) and Cook–Weisberg (1983) tests for heteroscedasticity. The results indicate rejection of the null hypothesis, suggesting the presence of autocorrelation and heteroscedasticity in the model.

To correct for the bias due to autocorrelation and heteroscedasticity, and for consistency of results for each country, we estimate the heteroscedasticity and autocorrelation consistent (HAC) standard errors following Newey and West (1987), for all countries.

To examine the relationship between local oil price shocks of each country and stock market returns, we use oil price shocks constructed using Ready's (2018) methodology in the model. Table 6 contains the results of the regression from equation (37), analysing the relationship between stock market returns and oil price shocks driven by local supply and local demand shocks with Newey and West (1987) HAC standard errors. We examine the model for each country separately. The results suggest that local demand shocks have a highly significant positive impact on stock market returns for all countries in our sample. The relationship between demand shocks and stock market returns is strongly significant at the 1% level in all countries. This finding suggests that an increase in oil prices from the level of oil demand has a statistically significant effect on higher stock market returns in both oil-importing and

Figure 2: Historical decomposition of structural shocks constructed from Ready's (2018) methodology

Oil price shocks are defined into three shocks: oil supply shock, oil demand shock and oil risk shock. All shocks are scaled to annual frequency.

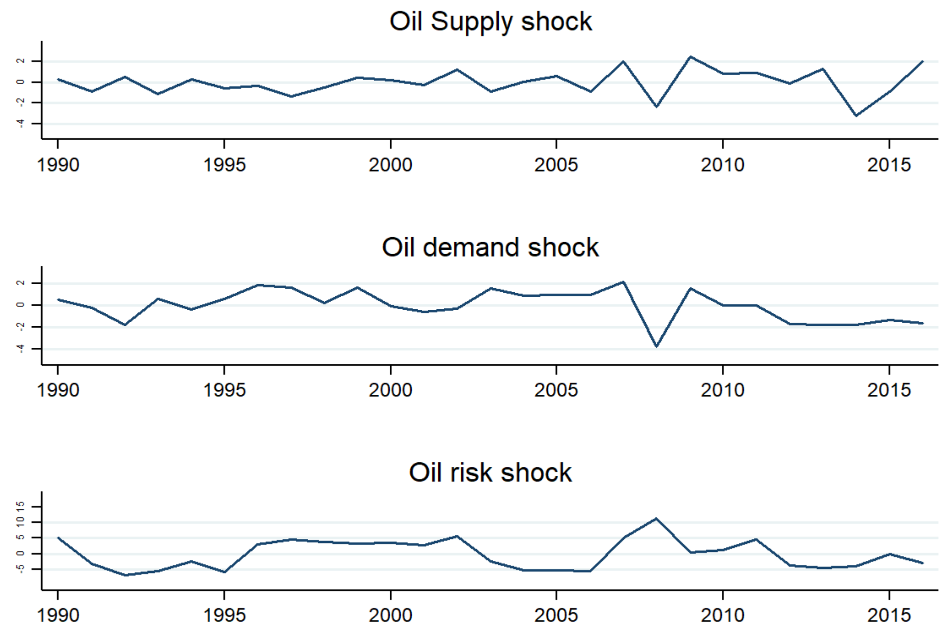
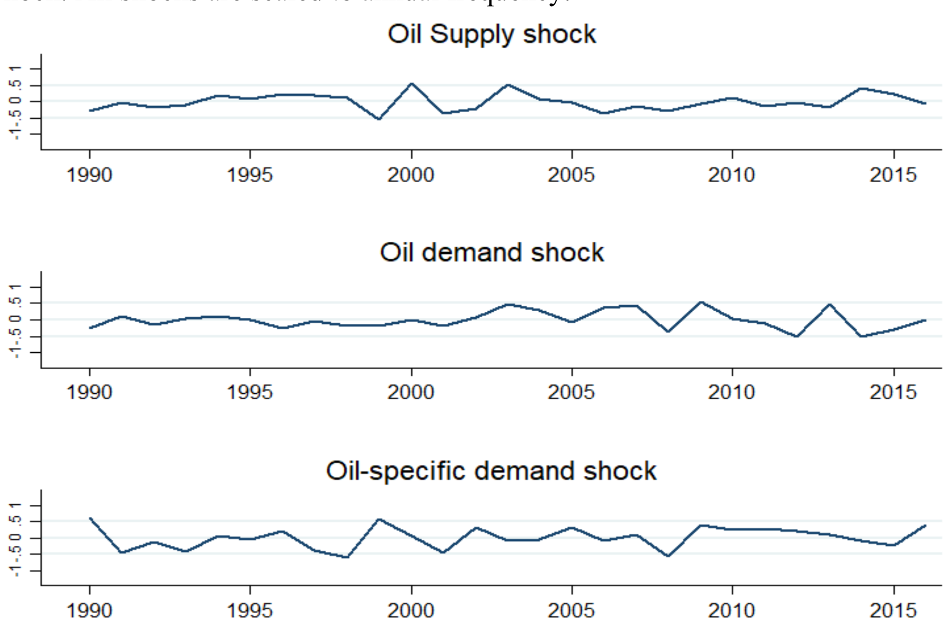


Figure 3: Historical decomposition of structural shocks constructed from Kilian's (2009) methodology

Oil price shocks are defined into three shocks: oil supply shock, oil demand shock and oil-specific demand shock. All shocks are scaled to annual frequency.



oil-exporting countries. This result is consistent with most of the previous studies. For example, Wang et al. (2013) reported that aggregate demand shocks have a positive persistent effect on stock market returns in both oil-importing and exporting countries. Kilian and Park (2009) also argued that higher oil prices from demand shocks are positively related to equity returns.

On the other hand, the response of stock market returns to supply shocks is different. There is a significant positive relationship between oil supply shocks and stock market returns in all oil-exporting countries. Canada, Russia and Kuwait exhibit a significant relationship at the 1% level while Mexico, Norway and Saudi Arabia exhibit a significant relationship at the 10% significance level. This finding suggests that increases in oil prices driven by supply shocks initially raise oil-exporting countries' revenue and their stock prices. This is consistent with Park and Ratti (2008), Talukdar and Sunyaeva (2011) and Güntner (2014) who all found that oil exporters receive benefits from higher oil prices.

For oil-importing countries, we found a significant negative effect of supply shocks on stock markets in the U.S., U.K. and Germany. This result is consistent with the findings from Ready (2018) and Kilian and Park (2009) who also found that supply shocks have a negative impact on aggregate stock market returns in the U.S. It is intuitive that increasing oil prices due to stagnation of oil production leads to increases in industry costs and decreases in firm profits and equity returns in oil-importing countries. In contrast, there is a significant positive effect of supply shocks on the stock market in Korea, indicating that increasing return of stock prices in this market results from higher oil prices driven by supply shocks.

Table 6: The impact of local oil price shocks constructed by Ready's (2018) methodology on stock market return in major oil-importing and oil-exporting countries

This table reports the OLS regression results from the equation $R_t^{Mkt} = \alpha + \beta_d d_t + \beta_s s_t + \beta_{VIX}\varepsilon_{VIX,t}$ which analyses the impact of oil price shocks driven by supply shocks and demand shocks on stock market returns in 15 major oil-importing and oil-exporting countries. The regression incorporates HAC Newey-West (1987) standard errors. The constructed supply and demand shocks are defined as in Section 3.2. T-statistics are in the parentheses. ***, **, * denotes statistical significance at the 1%, 5% and 10% level, respectively.

	Supply	Demand	Risk	Constant	Observation	Adjusted R-squared
Oil-importing countries						
U.S.	-0.001**	0.005***	-0.000***	0.006***	323	0.357
	(-2.128)	(10.782)	(-2.418)	(3.165)		
India	0.000	0.533***	-0.001***	0.003	105	0.329
	(0.085)	(4.554)	(-4.324)	(0.587)		
Japan	-0.001	0.394***	-0.001***	-0.002	323	0.283
	(-0.826)	(6.878)	(-8.700)	(-0.631)		
Korea	0.001**	0.499***	0.000**	0.003	167	0.332
	(2.030)	(7.267)	(-2.201)	(1.035)		
U.K.	-0.001*	0.394***	-0.001***	-0.001	203	0.531
	(-1.768)	(9.307)	(-8.838)	(-0.284)		
France	0.000	0.181***	-0.002***	-0.001	203	0.465
	(0.090)	(2.897)	(-13.809)	(-0.372)		
Germany	-0.001*	0.005***	-0.001***	0.007**	299	0.258
	(-1.878)	(5.703)	(-6.767)	(2.216)		
Italy	0.000	0.539***	-0.000**	-0.003	215	0.279
	(0.582)	(8.499)	(-1.976)	(-0.831)		
China	-0.000	0.315***	0.010***	0.001	216	0.933
	(-0.095)	(4.293)	(48.545)	(0.296)		
Oil-exporting countries						
Canada	0.002***	0.125***	-0.002***	0.005**	168	0.416
	(4.131)	(2.905)	(-8.585)	(2.266)		
Mexico	0.001*	0.444***	-0.001***	0.010***	152	0.367
	(1.897)	(7.069)	(-6.263)	(2.846)		
Norway	0.001*	0.665***	-0.001***	0.009***	299	0.475
	(1.877)	(13.379)	(-7.178)	(3.422)		
Kuwait	0.003***	0.180***	-0.000***	0.007*	203	0.114
	(3.570)	(2.249)	(-1.854)	(1.941)		
Saudi Arabia	0.002*	0.476***	-0.001***	0.007	217	0.172
	(1.762)	(4.790)	(-3.533)	(1.456)		
Russia	0.002***	0.919***	0.000	0.006	131	0.540
	(2.153)	(9.446)	(0.092)	(1.132)		

A plausible explanation for this is that since Korea almost entirely relies on crude oil imports to meet their oil demands because of insufficient domestic resources, Korea holds the strategies and commercial oil reserves to reduce the volatility of oil supply disruptions and oil price fluctuations. Moreover, the Korea-Oil Producing Nation Exchange (KOPEX) has organised to maintain good relationships with oil exporters, especially with the Middle East which is the main oil supplier of Korea (84% of the total oil import), as well as the Korea National Oil Corporation (KNOC), a state-owned oil company, and a private oil company engaged in global exploration and production (E&P) projects, in order to compensate the domestic oil reserve shortage and to secure oil supply. Thus, an increase in oil prices does not lead to a decrease in Korean stock market returns.

For the remaining countries, both oil-importing and exporting, there is no significant relationship between supply shocks and market returns. These results agree with Wang et al. (2013), Jung and Park (2011) and Bastianin et al. (2016) who all found no significant impact of oil supply shocks on market returns.

Overall, the results confirm that demand shocks have more persistent and stronger effects on stock market returns than supply shocks. Oil supply shocks have a relatively small or no significant impact on national stock market returns. This finding is generally consistent with Kilian (2008), Jung and Park (2011), Wang et al. (2013) and Hitzemann (2016) who all reported that oil supply shocks do not play a major role in changing oil prices and have a less significant effect on stock market returns since negative oil supply shocks can be offset by subsequent positive oil supply shocks. For example, the evidence from the Venezuela crisis in 2002 and the Iraq war in 2003 shows that production shortfalls are not followed by oil price changes (Kilian 2008). A possible explanation is that oil production disruption has only a temporary effect on oil prices. Thus, there is no significant effect of oil supply shocks on equity returns for both oil-importing and oil-exporting countries.

5.4. Global oil price shocks and stock market returns

Next, we examine the relationship between global oil price shocks constructed using Kilian's (2009) methodology and stock market returns by running OLS regression with HAC standard errors in equation (38). The findings are shown in Table 7. It can be seen that oil-specific demand shocks have a significant positive impact on stock market returns in all countries in our sample, except for Germany and China which are oil-importing countries. This confirms that a shift in expectation of precautionary demands leads to higher oil prices. This benefits oil-exporting countries in that they can receive higher revenue from this situation which drives up stock prices. In contrast with previous studies which have reported that stock market returns are depressed by oil-specific demand shocks (see Jung & Park 2011; ; Güntner 2014; Kilian & Park 2009; Wang et al. 2013), our results show that there is a significant positive effect of precautionary demand shocks on the stock market in seven oil-importing countries (U.S., India, Japan, Korea, U.K., France and Italy), while Germany and China exhibit a negative relationship. This suggests that the economic growth in these countries is greater than the effect of oil-specific demand shocks; thus, oil prices driven by precautionary demands do not decrease oil consumption and stock market returns in oil-importing countries, except for Germany and China. The energy market in China is characterised by low efficiency, suggesting that a shift in expectation of supply shortfall leads to a negative impact on stock market returns.

The impact of aggregate demand shocks on stock market returns is significant and positive in most countries, including both oil-exporting and oil-importing countries. For oil-exporting countries, the positive relationships in Norway and Kuwait were significant at the 1% level while the other countries in our sample were significant at the 10% level. With higher real economic activity, there is higher oil demand in the market which increases oil prices and stock prices. In contrast, the response to oil demand shocks in oil-importing countries is significant and positive for most countries (India, Japan, Korea, U.K. and France). Note that there are no significant effects in the U.S., Germany, Italy and China. In fact, an increase in oil prices, if it arises from an increase in global real economic activity, leads to higher production costs which have a negative effect in oil-importing countries. However, higher oil prices also result in lower oil demand. As a consequence, lower demand is likely to offset the negative effects from higher oil prices with a positive effect from growth in economic activity. Thus, oil-importing countries exhibit a positive impact on stock market returns if oil price changes are driven by aggregate demand shocks.

The lack of significant impact of oil price shocks in oil-importing countries, such as China, may be explained by the fact that China's stock market has low efficiency because the Chinese government and authorities intervene in the stock market (Chen & Shih 2002; Groenewold et al. 2003; Niblock & Sloan 2007). Thus, China's stock market is under strong control from the government and securities regulatory systems, rather than being controlled by market mechanisms. Moreover, the stock market in China has a limited number of shares for foreign investors to invest in. Although China has the world's second-largest stock market value, with growth rates of market capitalisation of approximately 1,479% from 2003 to 2016[11], the majority of China's stock market returns come from the domestic investors. Thus, China's stock market returns are not affected by global oil demand shocks.

A plausible explanation for the lack of effects on stock market returns in the U.S., Germany and Italy is that the market capitalisation of these stock markets has fallen during the period 2003-2016; for example, U.S. stock market returns accounted for

[11] The growth rate of total stock market capitalisation was obtained from Bloomberg.

36% of the total world market value in 2016, which is a decrease from 45% in 2003. Similarly, market capitalisation in Germany decreased from 3.3% in 2003 to 2.7% in 2016. Therefore, oil price increases driven by higher demand are not likely to increase equity return as the growth in real economic activity in these countries is relatively low.

There is no significant impact of oil supply shocks on stock market returns for most countries. Among oil-exporting countries, Norway is the only country in our sample showing a negative significant effect on market returns at the 5% significant level; India, which is an oil-importing country, showed a similar relationship. This suggests that oil supply disruptions only have a relatively small effect on oil price changes, and no impact on stock market returns. This is consistent with the results in Section 5.2, showing the historical oil price shock evolution, whereby supply shocks account for only a small portion of total oil price variation. Moreover, the results for Norway and India show a significant negative relationship. In general, it is not surprising that India's stock market return decreases as a result of increases in oil prices driven by oil supply level disruption because India is the third biggest importer of crude oil in the world, and increasing oil prices will increase industry costs. On the other hand, Norway, which is an oil-exporting country, also exhibits a negative relationship between stock market returns and oil supply shocks. This result is different from the findings obtained with Ready's (2018) methodology, which show positive effects of supply shocks on stock market returns in all oil-exporting countries and negative effects in oil-importing countries.

Table 7: The impact of global oil price shocks constructed using Kilian's (2009) methodology on stock market returns in major oil-importing and oil-exporting countries

This table reports the OLS regression results from the equation $R_t^{Mkt} = \alpha + \beta_d d_t + \beta_s s_t + \beta_{specific} \varepsilon_{specific,t}$ analysing the impact of oil price shocks driven by supply shocks and demand shocks on stock market returns in 15 major oil-importing and oil-exporting countries. The regression incorporates HAC Newey-West (1987) standard errors. The constructed supply and demand shocks are defined as in Section 3.1. T-statistics are in the parentheses. ***, **, * denotes statistical significance at the 1%, 5% and 10% level, respectively.

	Supply	Demand	Specific demand	Constant	Observation	Adjusted R-squared
Oil-importing countries						
U.S.	0.003	0.005	0.004*	0.006**	318	0.015
	(1.062)	(1.336)	(1.789)	(2.537)		
India	-0.010**	0.007*	0.015***	0.011**	324	0.044
	(-2.026)	(1.664)	(3.444)	(2.445)		
Japan	-0.005	0.008**	0.006*	-0.002	318	0.023
	(-1.009)	(2.036)	(1.478)	(-0.527)		
Korea	-0.005	0.008*	0.011**	0.003	318	0.021
	(-1.009)	(1.885)	(2.299)	(0.774)		
U.K.	-0.003	0.005**	0.006**	0.003	318	0.027
	(-1.174)	(1.767)	(2.120)	(1.376)		
France	-0.003	0.006*	0.012***	0.003	318	0.033
	(-0.779)	(1.490)	(2.788)	(0.877)		
Germany	-0.001	0.003	-0.003	0.006	318	0.005
	(-0.280)	(0.748)	(-0.741)	(1.638)		
Italy	-0.007	0.004	0.014***	-0.003	227	0.050
	(-1.403)	(0.938)	(3.176)	(-0.594)		
China	0.006	0.007	-0.003	0.010	311	0.004
	(0.966)	(1.136)	(-0.449)	(1.461)		
Oil-exporting countries						
Canada	0.002	0.004*	0.006***	0.005**	323	0.322
	(0.644)	(1.685)	(2.319)	(1.999)		
Mexico	-0.006	0.007*	0.008**	0.013***	323	0.021
	(-1.481)	(1.979)	(1.983)	(3.314)		
Norway	-0.007**	0.010***	0.014***	0.007*	323	0.414
	(-2.530)	(2.619)	(3.420)	(1.913)		
Kuwait	-0.003	0.005***	0.008*	0.005*	253	0.029
	(-0.709)	(1.341)	(2.025)	(1.639)		
Saudi Arabia	0.001	0.007*	0.014***	0.006	263	0.041
	(0.201)	(1.658)	(2.615)	(1.186)		
Russia	0.003	0.012*	0.029***	0.012	230	0.275
	(0.359)	(2.382)	(4.854)	(1.572)		

5.5. Structural impulse responses of stock returns to local oil price shocks

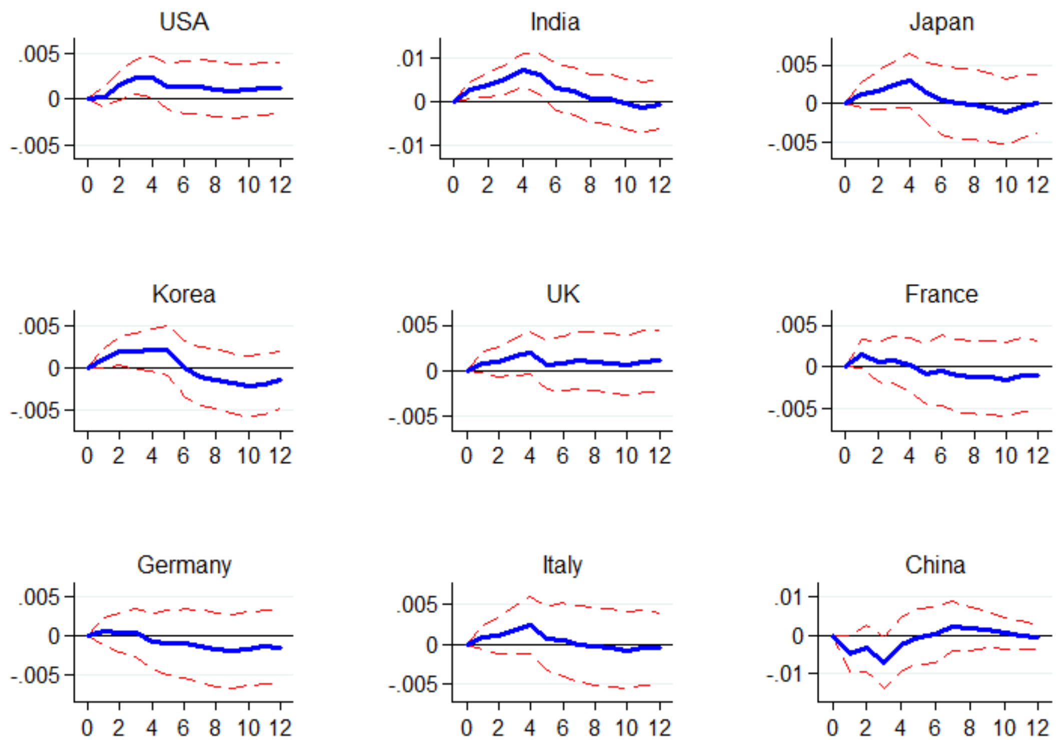
Using Ready's (2018) methodology for local oil shock construction, we investigate the response of stock market returns to these oil price shocks following equation (39). Figure 4 illustrates the impulse response of local oil supply shocks to stock market returns. The dashed lines represent 95% confidence intervals for the response of stock market returns to oil shocks. It can be seen that local oil supply shocks have a positive impact on oil-exporting countries, except for Russia. Although Russia is one of the largest oil exporters in the world, oil supply shocks lead to decreases in Russian stock market returns. This means that Russia does not benefit from higher oil prices in the initial period. This result suggests that oil-producing companies in Russia do not benefit from oil price increases, but lower oil prices harm the oil companies. This is because the Russian government implements a raising tax and requires dividend payment by oil companies. The government controls the oil companies and requires them to pay out a dividend, at a minimum of 50% of net income, which is twice that of normal dividend payments. Thus, Russian oil producing companies prefer the oil price to remain stable as there is a negative relationship between oil supply shocks and Russian market returns before stock market returns again increase within one year. On the other hand, the effects of supply shocks on stock market returns in oil-importing countries are less persistent than the effects in oil-exporting countries. Although oil-importing countries exhibit a positive response for several months, the effect in oil-exporting countries is short-lived before being set back to zero or becoming negative.

Moreover, as can be seen in Figure 5, the response of stock market returns to local oil demand shocks indicates that the stock market returns of oil exporters experience a more significant positive and persistent effect than the stock market returns of oil importers. However, Mexico is one oil exporter that exhibits a negative response in the initial period which becomes positive within six months. A plausible reason for this is that Mexico exports the least amount of crude oil among the oil exporters in our sample. Mexico's crude oil export accounts for only 6% of exportation revenue in Mexico; thus, Mexico receives lower revenue from increasing oil prices compared to other countries. For oil-importing countries, changes in oil prices driven by local oil demand shocks have less of an impact on stock market returns than in oil-exporting countries. Since growth in local oil demand shocks leads to increases in oil prices and industry costs, stock market returns of oil importers exhibit a temporary negative effect, which is absorbed and returns back to normal.

Figure 6 illustrates the cumulative effect of risk shocks, which are associated with changes in the market discount rate driven by the attitudes toward risk, on stock market returns. The results show that the patterns of response are different by country. Most countries have a negative response to risk shocks, except for the U.S. (oil-importing country) and Mexico (oil-exporting country). The negative effect on stock market returns is much stronger in oil-exporting countries. This suggests that increasing the discount rate leads to lower profit and negative market returns among oil producers.

Figure 4: Cumulative impulse response of stock market returns to oil supply shocks constructed using Ready's (2018) methodology

Oil-importing country



Oil-exporting country

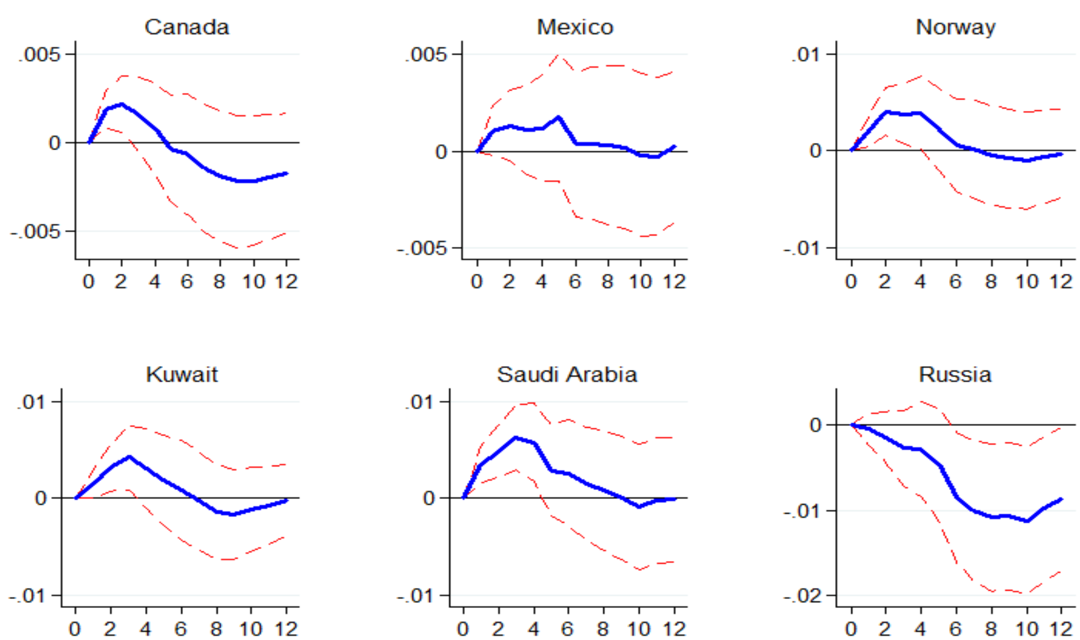
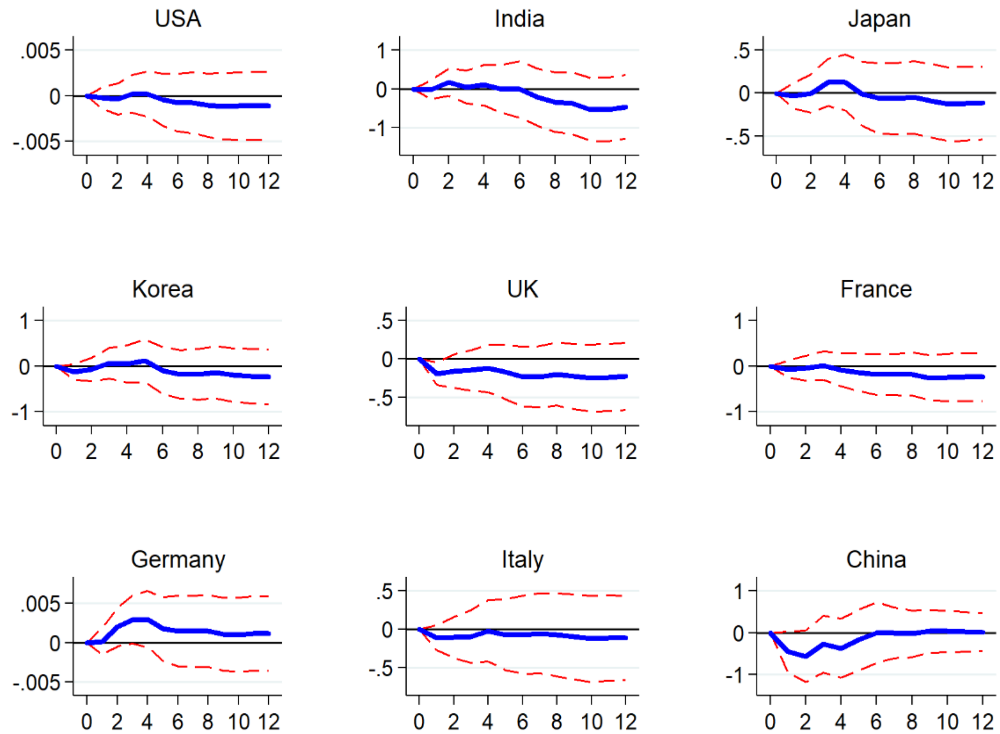


Figure 5: Cumulative impulse response of stock market returns to oil demand shocks constructed using Ready's (2018) approach.

Oil-importing country



Oil-exporting country

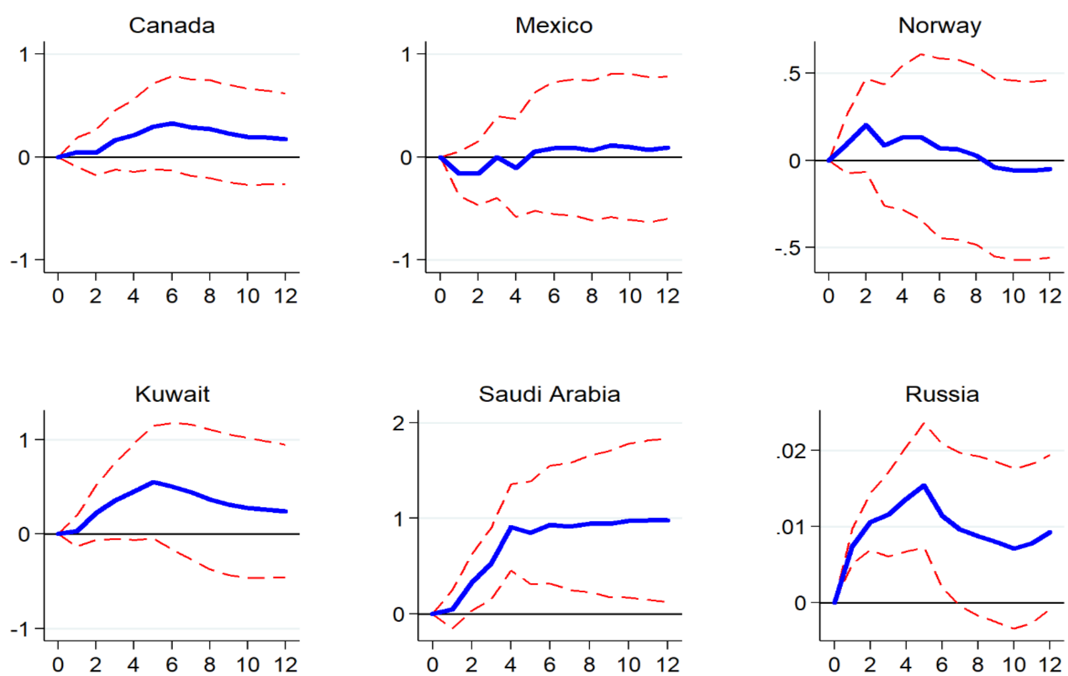
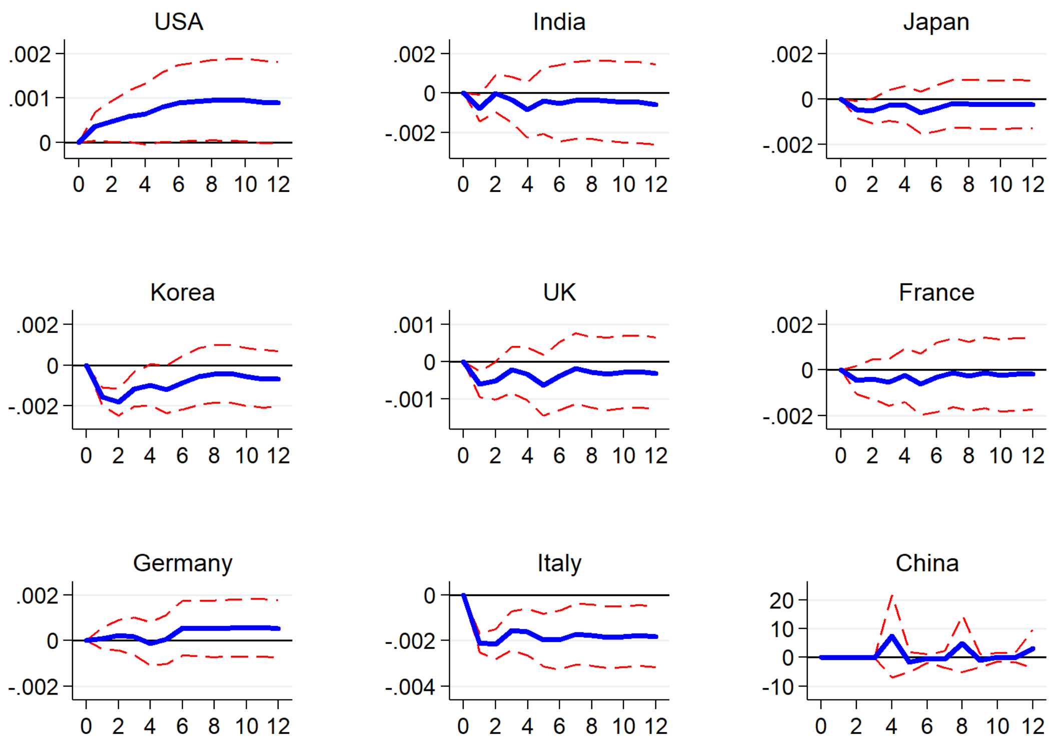
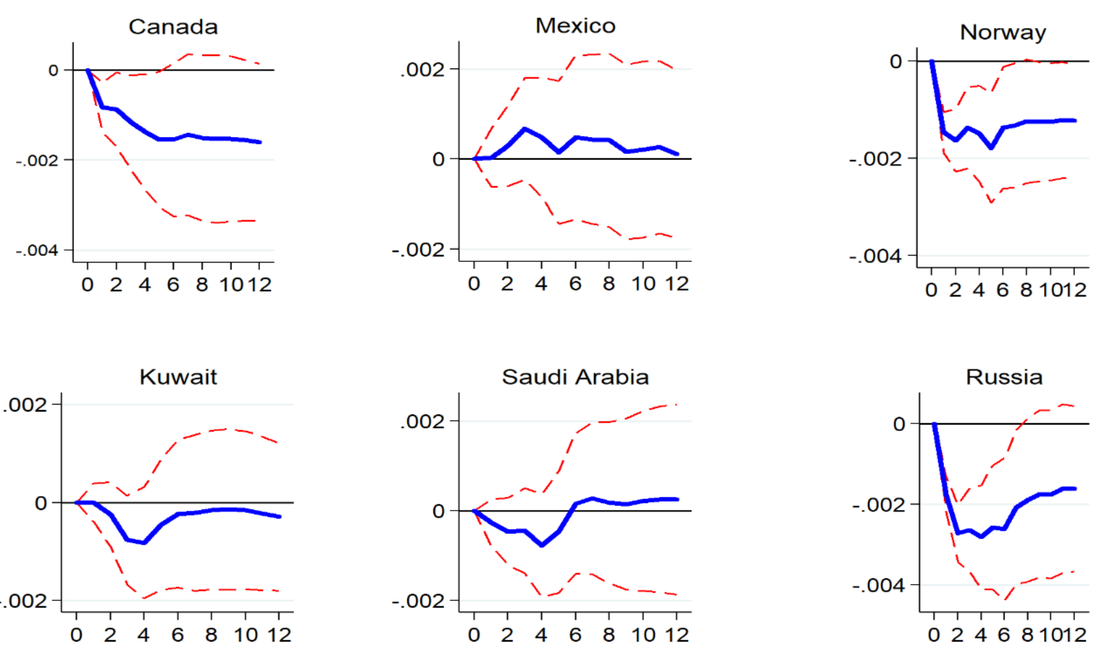


Figure 6: Cumulative impulse response of stock market returns to risk shocks constructed using Ready's (2018) methodology

Oil-importing country



Oil-exporting country



5.6. Structural impulse responses of stock returns to global oil price shocks

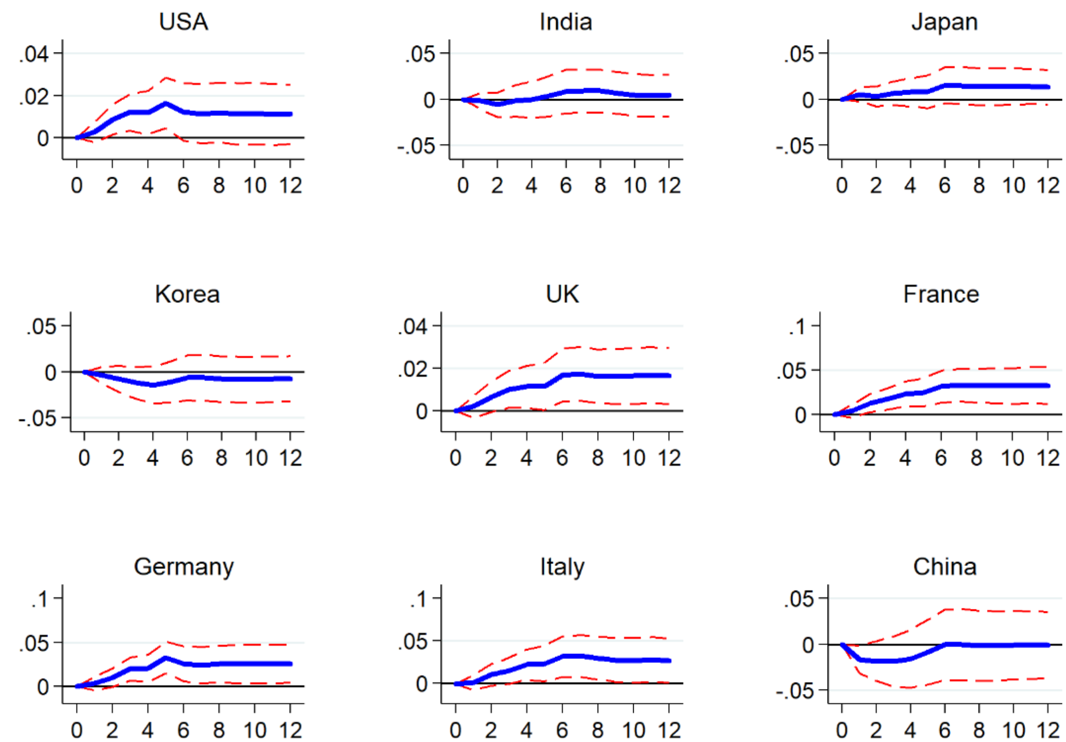
We examine the response of stock market returns to global oil supply shocks, global oil demand shocks and global oil-specific demand shocks under SVAR specifications using Kilian's (2009) approach. Figure 7 shows the impulse response functions of stock market returns in each country to global oil supply shocks following equation (40). The red dashed lines represent 95% confidence intervals for the response of stock market returns to oil shocks. It can be seen that oil supply shocks have a positive impact on stock market returns in most oil-importing countries within one month, except India, Korea and China. In the U.S. and Germany, market returns exhibit a negative response in the next six months. In contrast, the stock market returns in India, Korea and China, which have the largest economic growth in the world, are negatively affected by oil supply shocks before showing a positive impact for the following two months for India and China, and for the following four months for Korea. China shows the largest decline in stock market returns. This outcome is not surprising as China is the second largest oil-importing country in the world; thus, oil supply disruption leading to higher oil prices and higher production costs is expected to have a larger effect in China. For oil-exporting countries, oil supply shocks raise stock market returns in Canada, Norway, Kuwait and Russia within one month, whereas Mexico and Saudi Arabia show positive responses within two months. It takes approximately eight months to adjust the impulse response back to zero for all countries.

The impulse responses of stock market returns to aggregate oil demand shocks are shown in Figure 8. The impact of oil demand shocks is the same for both oil-importing and oil-exporting countries. In line with the results in Section 5.4, stock market returns in all countries respond to demand-driven oil price shocks in a positive way. Moreover, the graphs show that the positive effect of oil demand shocks on stock market returns in oil-exporting countries appears to be stronger compared to the effect in oil-importing countries. This finding suggests that the expansion of economic activity in oil-importing countries leads to an increase in consumption and oil demand. This results in importation of higher levels of oil from oil-exporting countries, corresponding to a transfer of revenue from oil-importing countries to oil-exporting countries. Thus, the positive impact on stock market returns in oil-exporting countries is greater than in oil-importing countries. Overall, after the initial increases, the stock market response returns to zero within six months.

Figure 9 presents the response of stock market returns to oil-specific demand shocks. Stock market returns among oil-exporting countries in our sample respond to precautionary demand shocks positively in the first month, before then exhibiting a negative response. This is consistent with the fact that increases in oil prices driven by unexpected changes in oil supply lead to higher revenue for oil-exporting countries. For oil-importing countries, the response of stock market returns is positive within the first month in seven countries (U.S., India, Japan, Korea, U.K., Italy and China), while there is a negative response in France and Germany in the six months after the precautionary demand shock, before reverting back to zero.

Figure 7: Cumulative impulse response of stock market returns to oil supply shocks constructed using Kilian's (2009) approach

Oil-importing country



Oil-exporting country

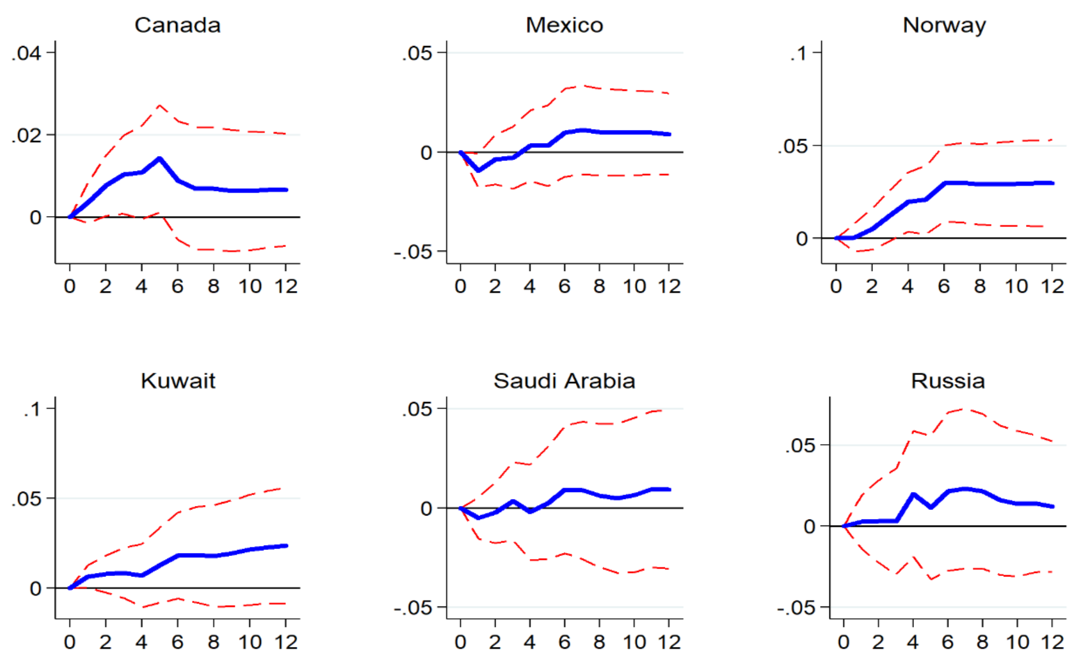
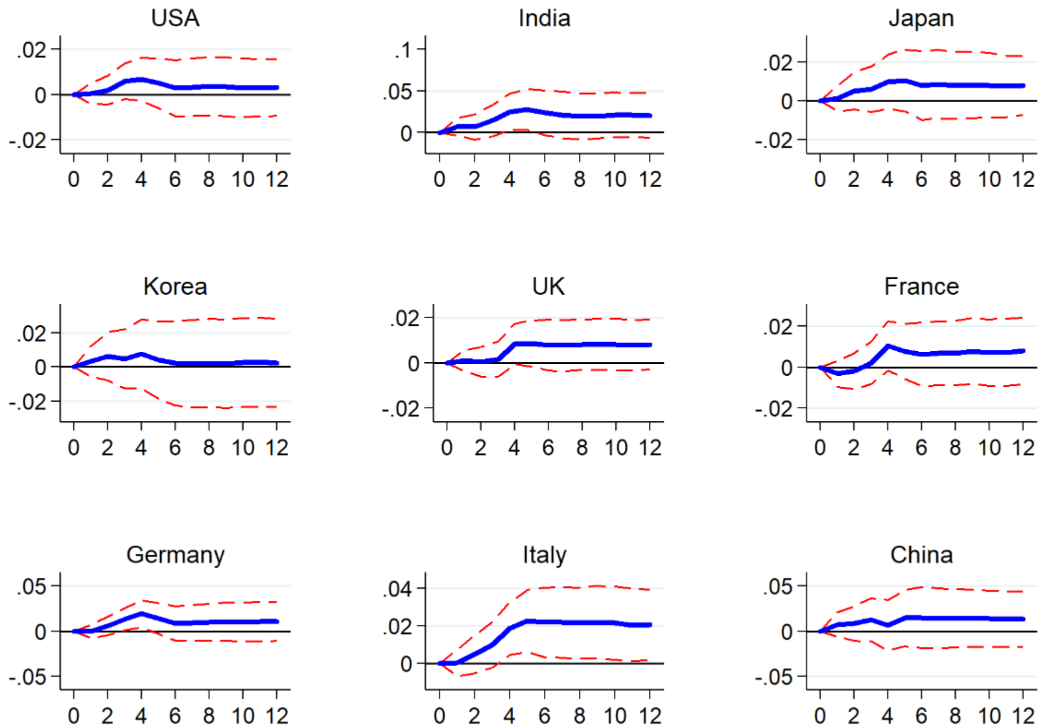


Figure 8: Cumulative impulse response of stock market returns to oil demand shocks constructed using Kilian's (2009) approach

Oil-importing country



Oil-exporting country

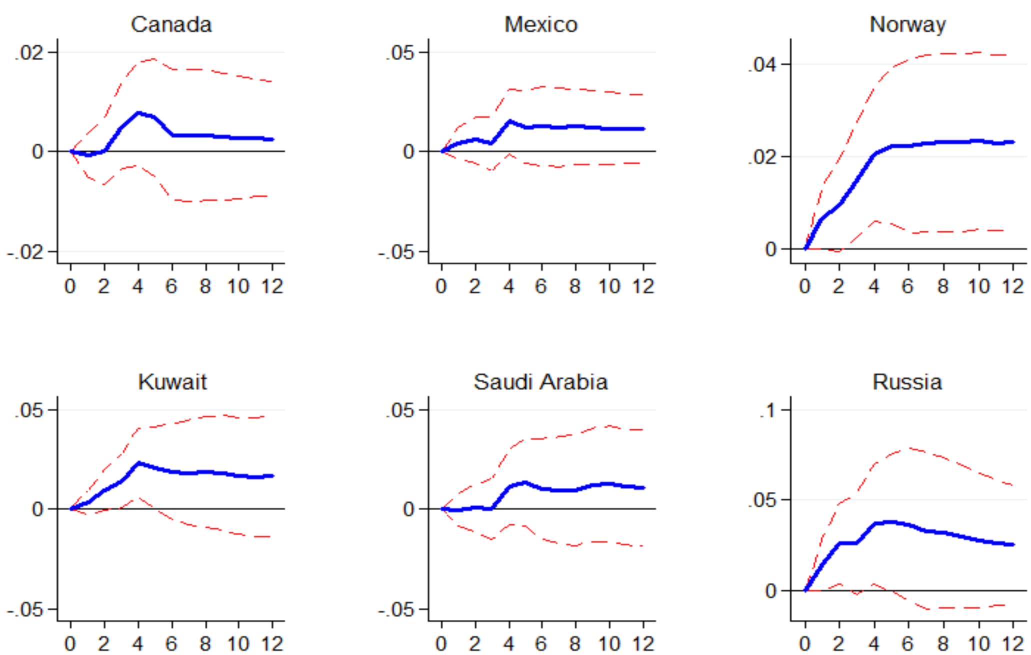
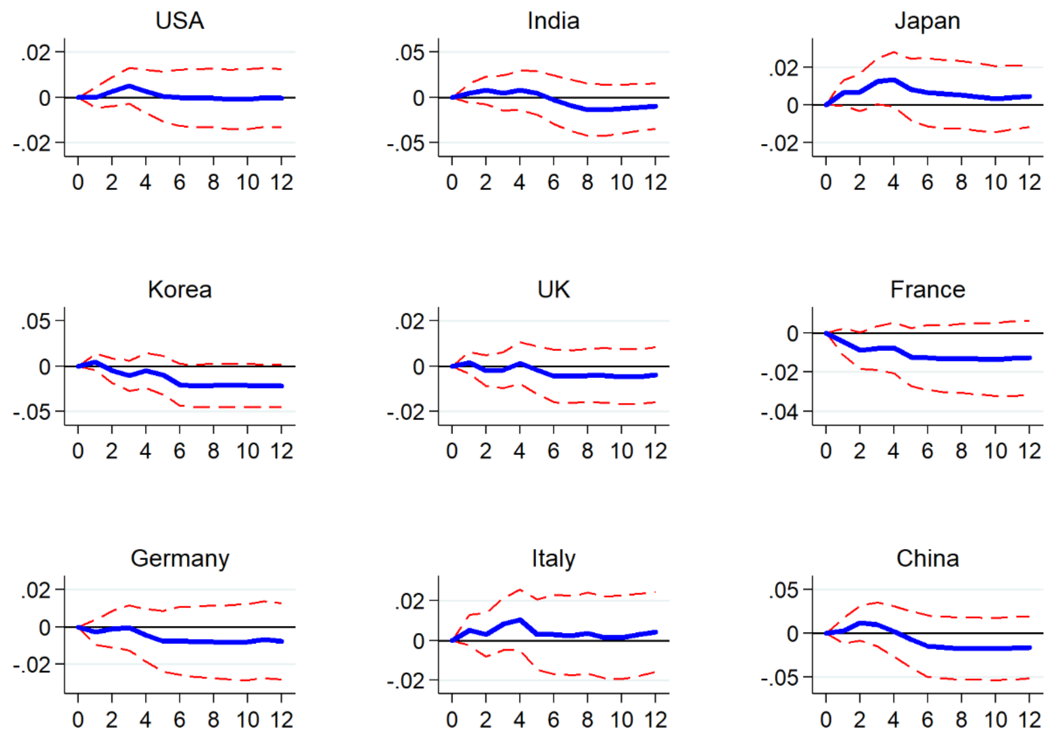
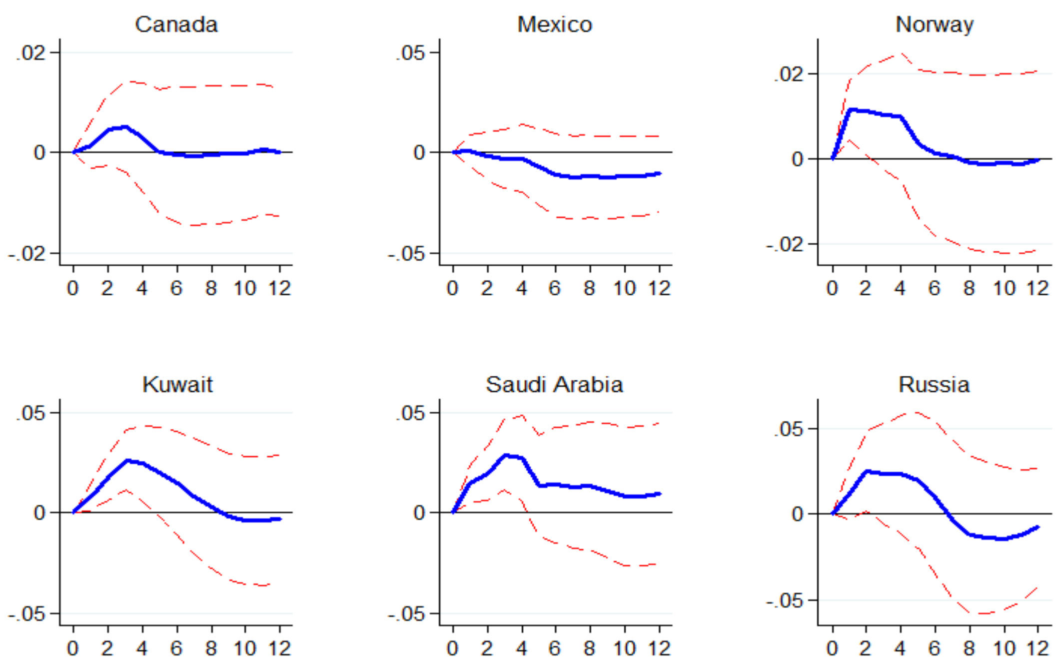


Figure 9: Cumulative impulse response of stock market returns to oil-specific shocks constructed using Kilian's (2009) approach

Oil-importing country



Oil-exporting country



5.7. Comparison of the impact of local and global oil price shocks on stock market returns

In this section, we compare the results for the relationship between stock market returns and global oil price shocks constructed using Kilian's (2009) approach with local oil price shocks constructed using Ready's (2018) approach. Overall, it is noteworthy that local oil price shocks have a stronger impact than global oil price shocks, especially in oil-exporting countries.

First, we examine the results in Sections 5.3 and 5.4 for oil-exporting countries. It can be seen that there is no difference in the impact of local demand shocks and global demand shocks on stock market returns. On the other hand, global demand shocks using Kilian's (2009) shock construction cannot capture the significant impacts on stock returns in four of the oil-importing countries (U.S., Germany, Italy and China), whereas there is a significant positive relationship between local oil demand shocks and stock market returns for all oil-importing countries.

Second, the relationship between oil supply shocks and stock market returns remains inconclusive for both local and global oil shocks. Local oil supply shocks have a significant positive effect on five oil-exporting countries (Canada, Norway, Saudi Arabia, Mexico and Russia), while the relationship between local oil supply shocks and stock returns in oil-importing countries is not consistent among the countries. A significant negative effect is observed in the U.S., Germany and U.K., but there is a positive relationship in Korea. In contrast, global oil supply shocks have only significant negative relationships with stock returns in Norway (oil-exporting country) and India (oil-importing country). This is different from local oil price shocks, whereby a significant positive relationship was observed for Norway and an insignificant positive relationship for India.

We explain the difference between stock market returns and oil price shocks in each country in the following section.

5.7.1. Local oil demand shocks - Global oil demand shocks

Recall from Sections 5.3 and 5.4 that we would expect that local oil demand shocks and global oil demand shocks exhibit positive relationships with the stock market returns of oil exporters. Figure A.3 in Appendix B plots each stock market return against oil price shocks driven by demand and supply shocks. The blue and red dashed lines represent oil supply shocks and oil demand shocks, respectively. The green solid line represents stock market returns. These figures support our expectation, showing that both local and global oil demand shocks (red line) have a positive relationship with the stock market return of each oil-exporting country. The higher demand drives higher stock prices while it also drives oil prices up. Similar to market returns of oil importers, there is a positive relationship between demand shocks and market returns for all countries. Although four countries (U.S., Germany, Italy, China) out of nine countries show an insignificant impact of global demand shocks, there are still positive relationships consistent with local demand shocks.

During the 2007-2009 global financial crisis, both local and global oil demand shocks exhibited similar magnitude effects on all stock market returns; as shown in Figure A.3, stock market returns showed downward movement in response to a significant drop in oil demand. On the other hand, the main difference in the effects of local and global demand shocks was during the period 2011–2015. Global demand shocks had a relatively larger impact on stock market returns. There was a sharp drop in global demand shocks, larger than for local demand shocks. In this period, oil prices dropped significantly due to an oversupply of crude oil, appreciation of the U.S. dollar and decline in demand. Thus, global oil price shocks capture that the decrease in oil prices is driven by decreases in global oil demand rather than an oversupply of crude oil because the economies of developed countries weakened and the rapid economic growth in emerging countries, especially in China which is the world's largest oil importer, became slower after 2010. This led to a huge decline in global oil demand. Nevertheless, our findings show that stock market returns are more responsive to local oil demand shocks than global oil demand shocks.

5.7.2. Local oil supply shocks – Global oil supply shocks

Next, Figure A.3 also illustrates the relationship between local and global oil supply shocks and stock market returns. This figure supports our findings in Sections 5.3 and 5.4 that stock market returns are more responsive to local supply shocks than global oil price shocks in both oil-exporting and oil-importing countries. Stock market returns of oil-exporters are positively related with local supply shocks, while the relationship in oil-importing countries is both positive and negative. On the other hand, global supply shocks have a negative impact on stock market returns in oil-importing countries, except for the U.S. and China, the two largest oil importers in the world.

Figure A.3 shows that global oil supply shocks exhibited a large impact on stock market returns in late 1997 (the Asian financial crisis). This is generally consistent with the fact that before the Asian financial crisis, there was strong oil demand growth corresponding to rapid economic growth. Then, crude oil production for both OPEC and non-OPEC countries gradually increased and oil producers planned to develop their capacity for oil production. When the Asian financial crisis occurred, declining economic growth and oil demand led to lower revenue for oil exporters. Consequently, oil producers had less revenue to develop their oil reserves and thus, reduced their oil production in response to global oil demand stagnation. Thus, global supply shocks have a much greater impact on stock market returns than local supply shocks.

On the other hand, in 2014, local oil supply shocks had a much greater effect on stock market returns than global supply shocks. Since there was an oversupply of crude oil during this period, the oil inventory has increased to more than the expectation of each country. These local supply shocks led to a decline in stock market returns.

5.8. Local oil price shocks and exchange rates

In order to further examine the relationship between oil price shocks and stock market returns, this section provides more insight into whether the impact of oil price shocks on exchange rates differs across countries. First, we start with the relationship between local oil price shocks and exchange rates by estimating equation (41).

Table 8 reports the impact of local oil price shocks on the bilateral exchange rate against the U.S. dollar. First, the findings show that that local demand shocks have a negative effect on exchange rates in both oil-importing and oil-exporting countries, suggesting that local demand shocks correspond to an increase in oil prices which cause depreciation of the U.S. dollar against other currencies. This result is similar to Basher et al. (2012), Habib et al. (2016) and Su et al. (2016). For oil-exporting countries, there is a significant negative relationship between local demand shocks and exchange rates in Canada, Mexico, Norway and Kuwait, while Saudi Arabia and Russia show no significant relationship. This negative local demand shock leads to an improvement in trade balance and a subsequent appreciation of oil exporter's currency. For oil-importing countries, local demand shocks were found to have a significant negative impact on the bilateral exchange rate against the U.S. dollar in India, Korea, the U.K., France, Germany and Italy; however, Japan and China did not show significant depreciation of the U.S. dollar relative to local currency. This is consistent with Basher et al. (2016) who did not find a significant effect of demand shocks on exchange rates in Japan. For China, a plausible explanation is that although

China is the largest oil importer, importing 116.2 billion U.S. dollars' worth of oil in 2016, the exchange rate regime of China is a combination of fixed and floating. China had a purely fixed exchange rate regime from 1994–2005 by pegging the value of the yuan to the U.S. dollar at approximately 8.25 yuan per USD. This explains why the exchange rate in China was not affected significantly by oil price shocks. Overall, positive local demand shocks correspond to a rise in oil prices and cause a large depreciation of the U.S. dollar as well as local currency appreciation; this implies that the value of imports is cheaper, leading to a deterioration in production of crude oil; the oil component of the trade balance cannot be offset by an increase in non-oil trade balance (Basher et al. 2016).

Local supply shocks had a significant negative impact on exchange rates in all oil-exporting countries in our sample. Our results suggest that oil price increases driven by local supply shocks cause a depreciation of the U.S. dollar relative to the oil exporter's currency and an improvement of their trade balance. On the other hand, local supply shocks also had a significant negative effect on exchange rates in oil-importing countries, except for India and Japan. There was no significant effect in both of these countries; however, there was a positive relationship between supply shocks and exchange rates in Japan. A plausible explanation for this is that although Japan is the third largest oil consumer and importer, following China and the U.S., and imported 50.8 billion U.S. dollars of oil in 2016, which represents the highest value among Japan's total imports, Japan has a current trade account surplus and its reliance on nuclear energy could weaken the value of the Yen, corresponding to an appreciation of the U.S. dollar relative to local currency. Typically, our empirical results are inconsistent with the majority of previous studies which did not find any significant impact of oil supply shocks on exchange rates because previous research used global oil price shocks while our results in this section used local oil price shocks.

Table 8: The impact of local oil price shocks on exchange rates in major oil-importing and oil-exporting countries

This table reports the OLS regression results from equation: $x_{it} = \alpha + \beta_d d_t + \beta_s s_t + \beta_{VIX}\varepsilon_{VIX,t}$ analysing the impact of oil price shocks driven by supply shocks and demand shocks on the bilateral exchange rate against the USD in 15 major oil-importing and oil-exporting countries. The regression incorporates HAC Newey-West (1987) standard errors. The constructed supply and demand shocks are defined as in Section 3.2. T-statistics are in the parentheses. ***, **, * denotes statistical significance at the 1%, 5% and 10% level, respectively.

	Supply	Demand	Risk	Constant	Obs	Adj R-squared
Oil-importing countries						
India	-0.036	-9.506***	0.019*	0.513***	105	0.106
	(-0.943)	(-3.002)	(1.818)	(2.621)		
Japan	0.010	-1.292	-0.022***	-0.062	323	0.018
	(0.250)	(-0.477)	(-2.630)	(-0.422)		
Korea	-0.106***	-16.175***	0.044***	0.027	167	0.300
	(-2.641)	(-4.700)	(2.677)	(0.168)		
U.K.	-0.091***	-15.660***	0.016*	0.141	203	0.218
	(-3.086)	(-5.763)	(2.330)	(1.022)		
France	-0.126***	-10.332***	0.015*	-0.016	203	0.128
	(-3.495)	(-3.983)	(1.679)	(-0.103)		
Germany	-0.140***	-0.127***	-0.000	0.058	299	0.116
	(-4.323)	(-3.968)	(-0.061)	(0.445)		
Italy	-0.121***	-10.081***	0.009	0.049	203	0.218
	(-3.417)	(-4.192)	(1.022)	(0.316)		
China	-0.020***	-0.807	-0.001	-0.083***	216	0.040
	(-2.840)	(-1.587)	(-0.433)	(-2.591)		
Oil-exporting countries						
Canada	-0.149***	-16.235***	0.020*	-0.092	168	0.379
	(-5.132)	(-7.758)	(1.923)	(-0.722)		
Mexico	-0.113***	-11.959***	0.086***	0.370**	152	0.377
	(-3.287)	(-4.192)	(4.259)	(2.224)		
Norway	-0.235***	-14.245***	0.014*	0.103	299	0.248
	(-6.583)	(-6.175)	(1.544)	(0.812)		
Kuwait	-0.021**	-2.267***	0.004	0.034	131	0.090
	(-2.237)	(-2.926)	(1.030)	(0.664)		
Saudi Arabia	-0.002**	-0.063	-0.000	0.000	131	0.026
	(-2.364)	(-0.772)	(-0.023)	(0.014)		
Russia	-0.250***	-0.079	0.070***	0.577*	131	0.213
	(-3.160)	(-0.958)	(3.576)	(1.712)		

5.9. Global oil price shocks and exchange rates

The results of equation (42), showing the relationship between global oil price shocks and bilateral exchange rates against the U.S. dollar, are reported in Table 9. We found that oil-specific demand shocks have a significant negative impact on nominal exchange rates for all oil-exporting countries. This finding is in line with the empirical results of Atems et al. (2015) and Su et al. (2016) who found that oil-specific demand shocks bring about an appreciation of local currency relative to the U.S. dollar or U.S. dollar depreciation. Since oil price increases driven by precautionary demand shocks cause trade account surpluses for oil exporters, the supply of the U.S. dollar relative to local currency increases as oil price is quoted in U.S. dollars, and subsequently leads to an appreciation of oil exporter's currency. On the other hand, for oil-importing countries, oil-specific demand shocks also have significant negative effect on exchange rates in seven out of the eight oil-importing countries (India, Korea, U.K., France, Germany, Italy and China). It is intuitive that oil-specific demand shocks associated with oil supply shortfalls lead to decreases in oil supply availability to export from the oil exporter. Thus, increases in oil prices driven by oil-specific demand shocks are bad news for oil-importing countries. These countries should reduce their oil import leading to a decrease in demand for the U.S. dollar, causing U.S. dollar depreciation relative to local currency. However, in Japan, oil-specific demand shocks have a negative effect, but this was not statistically significant. This result is consistent with Basher et al. (2016). A plausible explanation is that Japan is highly dependent on oil import from the Middle East, which accounts for 82% of Japan's total oil import. Moreover, Japan has a deal with Middle Eastern countries to cooperate with respect to nuclear security and technology transfer in exchange for long-term crude oil supply. Thus, the effect in Japan may be weaker than in other countries.

Table 9: The impact of global oil price shocks on exchange rates in major oil-importing and oil-exporting countries

This table reports the OLS regression results from equation: $x_{it} = \alpha + \beta_d \mathrm{u}_t^{\text{demand shock}} + \beta_s \mathrm{u}_t^{\text{supply shock}} + \beta_{specific} \mathrm{u}_t^{\text{specific demand shock}}$ analysing the impact of oil price shocks driven by supply shocks and demand shocks on the bilateral exchange rate against the USD in 15 major oil-importing and oil-exporting countries. The regression incorporates HAC Newey-West (1987) standard errors. The constructed supply and demand shocks are defined as in Section 3.1. T-statistics are in the parentheses. ***, **, * denotes statistical significance at the 1%, 5% and 10% level, respectively.

	Supply	Demand	Specific demand	Constant	Obs	Adj R-squared
Oil-importing countries						
India	-0.221**	0.099	-0.257**	0.428***	318	0.022
	(-2.237)	(0.759)	(-2.588)	(3.839)		
Japan	0.110	0.156	-0.029	-0.089	318	0.004
	(0.739)	(1.125)	(-0.161)	(-0.596)		
Korea	-0.261	0.147	-0.589***	0.157	318	0.034
	(-1.433)	(0.889)	(-2.441)	(0.895)		
U.K.	-0.219*	0.214*	-0.416***	0.099	318	0.040
	(-1.715)	(1.675)	(-3.258)	(0.775)		
France	-0.129	0.192	-0.477***	0.030	318	0.038
	(-0.961)	(1.431)	(-3.555)	(0.220)		
Germany	-0.132	0.198	-0.470***	0.030	318	0.036
	(-0.971)	(1.457)	(-3.450)	(0.224)		
Italy	-0.143	0.228	-0.455***	0.125	318	0.035
	(-1.061)	(1.637)	(-2.775)	(0.895)		
China	-0.028	0.026	-0.058***	-0.052**	318	0.022
	(-1.156)	(1.339)	(-2.628)	(-2.345)		
Oil-exporting countries						
Canada	-0.320***	0.145*	-0.591***	0.041	318	0.156
	(-2.413)	(1.659)	(-4.752)	(0.463)		
Mexico	-0.217	-0.086	-0.533***	0.621***	318	0.022
	(-1.176)	(-0.469)	(-2.727)	(3.371)		
Norway	-0.197	0.286**	-0.910***	0.088	318	0.135
	(-1.249)	(2.121)	(-5.321)	(0.656)		
Kuwait	0.029	0.041	-0.089***	0.013	309	0.021
	(0.744)	(1.191)	(-2.530)	(0.426)		
Saudi Arabia	-0.001	0.000	-0.005**	-0.000	315	0.011
	(-0.269)	(0.164)	(-2.118)	(-0.059)		
Russia	-0.096	0.212	-0.721*	2.077***	294	0.001
	(-0.270)	(0.490)	(-1.727)	(4.994)		

For global demand shocks, there was a positive relationship with bilateral exchange rates in both oil-importing countries and oil-exporting countries, although this was not statistically significant except in the U.K., Canada and Norway, which exhibited significant positive relationships' this indicates that an appreciation of the U.S. dollar relative to local currency follows global demand shocks. This is consistent with Charnavoki and Dolado (2014), Basher et al. (2016) and Su et al. (2016) who found significant positive relationships only in the U.K. and Canada, while there were no significant effects in other countries. This implies that global demand shocks affect the currency of both oil-importers and oil-exporters through changes in oil prices and changes in demand for other tradable goods. This leads to a depreciation of domestic currency.

In addition, the results indicate that global oil supply shocks have no significant impact on the exchange rate in most countries, except for India, the U.K. and Canada. This is consistent with results of Atems et al. (2015), Su et al. (2016) and Basher et al. (2016). Global oil supply shocks had a significant negative impact on the exchange rate in India, the U.K. (oil-importing country) and Canada (oil-exporting country). Overall, this finding is in line with Kilian (2009) who found that global oil supply shocks have less of an impact on the variation of oil prices, subsequently leading to less of an impact on output and no impact on inflation. Thus, this finding confirms that oil supply shocks have no impact on macroeconomic variables. Moreover, this result is consistent with the results in Section 5.4 whereby changes in oil prices driven by global supply shocks were found to have no impact on both exchange rates and stock market returns.

5.10. The overall impact of oil price shocks and exchange rates

In this section, we are interested in whether the response of the exchange rate to oil price shocks for oil-exporting countries overall in our sample is different from the response in oil-importing countries overall. We estimate equation (43) and apply time and country fixed effects to answer this question.

The result is shown in Table 10. The main focus of this result is the interaction term between the three different sources of oil price shocks, oil trade balance and oil exporter dummy. This measures the different response of exchange rates to identified oil price shocks for oil-exporting countries compared to oil-importing countries. Panel A presents the impact of local oil price shocks on exchange rates. We found that local demand shocks have a significant negative impact on the bilateral exchange rate against the USD in oil-exporting countries, indicating that local demand shocks lead to a depreciation in nominal exchange rates. This is consistent with the findings of Habib et al. (2016) and Su et al. (2016), and confirms our findings in Section 5.8 where we also found a significant negative impact for each oil-exporting country. Nevertheless, oil-importing countries experienced an appreciation of the U.S. dollar relative to local currency following local demand shocks. This result is consistent with Ghosh (2011), Lizardo and Mollick (2010) and Habib et al. (2016). This indicates that an increase in local oil demand causes a higher demand in U.S. dollar for oil importers, subsequently appreciating the U.S. dollar.

We found that local supply shocks have a significant negative impact on real exchange rates in oil-exporting countries. This is consistent with the fact that increases in oil prices due to lower production lead to weakening of the bilateral exchange rate against the U.S. dollar, which corresponds to appreciation of local currency. In contrast, local supply shocks have a significant positive impact on both nominal and real exchange rates in oil-importing countries. This result suggests that oil importers need a higher amount of U.S. dollars which would lead to an appreciation of the U.S. dollar relative to the oil importer's currency. The results for the effects of local supply shocks on exchange rates in both oil-exporting and oil-importing countries are inconsistent with previous studies which did not find any significant effects of oil supply shocks (Basher et al. 2016; Habib et al. 2016); however, we examined local supply shocks which is not same as the previous research. It can be inferred that local supply shocks have a greater significant impact on both oil-exporting and oil-importing countries than global supply shocks.

Panel B in Table 10 shows the relationship between global shocks and exchange rates. For oil-exporting countries, we did not find any significant impact of global demand shocks on both nominal exchange rates or real exchange rates, but the relationship between global demand shocks and both nominal and real exchange rates was positive. This implies that oil price increases driven by global demand shocks do not have much of an impact on exchange rates. Our findings are not completely in accordance with the results of Habib et al. (2016) who found a significant negative impact on real exchange rates, but there was no significant impact on nominal exchange rates, suggesting that oil exporters experience U.S. dollar depreciation following global demand shocks. A plausible explanation for these different results is that the number of oil-exporting countries in our sample (six countries) was less than the sample of countries in the previous study and our data covers more recent years.

On the other hand, the interaction term of oil supply shocks and oil trade balance with the dummy variable for oil exporters was negative and significant for real exchange rates but was not significant for nominal exchange rates. This result generally suggests that oil price increases due to oil supply shocks lead to higher revenue of oil exporting countries and trade balance surplus while domestic companies of oil exporters have to use local currency to pay their tax and all expenditures. Consequently, oil exporters will receive the U.S. dollar from oil importers as oil prices are quoted in U.S. dollars. Thus, oil exporters suffer from a massive loss of U.S. dollar depreciation or appreciation of local currency. Our results confirm the findings in Section 5.9. that global demand and global supply shocks have both positive and negative relationships with exchange rates, respectively. For oil-importing countries, there were no significant effects of global oil supply shocks and global oil demand shocks on both nominal and real exchange rates. This is consistent with Habib et al. (2016). This indicates that global oil shocks have less of an impact on exchange rates in oil-importing countries.

Table 10: The overall impact of both local and global oil price shocks on exchange rates in major oil-importing and oil-exporting countries

This table reports the pooled panel OLS regression results from equation: $x_{it} = k_i + \lambda_t + \beta x_{i,t-1} + \gamma y_{i,t-1} + \delta u_t y_{i,t-1} D_{it} + \varepsilon D_{it}^{crisis} + \eta D_{it} + \nu_{it}$ analysing the impact of oil price shocks driven by supply shocks and demand shocks on the bilateral exchange rate against the USD and the real effective exchange rates (REER) in 15 major oil-importing and oil-exporting countries. The data are based on quarterly measures. The constructed global and local oil shocks are defined as in Section 3.1 and 3.2, respectively, and are averaged to a quarterly basis. The model also includes time and country fixed effects. T-statistics are in the parentheses. ***, **, * denotes statistical significance at the 1%, 5% and 10% level, respectively.

Variables	Panel A Local oil price shocks		Panel B Global oil price shocks	
	USD	REER	USD	REER
Demand shock*Oil trade balance*Oil exporter	-0.967**	-0.355	0.161	0.098
	(1.977)	(0.916)	(1.469)	(0.949)
Supply shock*Oil trade balance*Oil exporter	-0.138	-0.432***	-0.014	-0.185*
	(-0.867)	(-2.893)	(-0.131)	(-1.908)
Risk shock*Oil trade balance*Oil exporter	-0.025	0.176	-0.037	-0.336**
	(-0.160)	(1.140)	(-0.235)	(-2.339)
Demand shock*Oil trade balance*Oil importer	0.257	0.805***	-0.048	0.044
	(1.107)	(2.897)	(-0.076)	(0.114)
Supply shock*Oil trade balance*Oil importer	2.088*	1.195**	-0.248	0.321
	(1.877)	(2.034)	(-0.376)	(0.951)
Risk shock*Oil trade balance*Oil importer	-0.530	-0.514	1.377**	1.122**
	(-0.796)	(-1.066)	(2.165)	(1.990)
Crisis dummy	-1.612	-1.293	-4.000*	-4.971***
	(-0.782)	(-0.682)	(-1.680)	(-2.586)
Exporter dummy	0.567	-0.640	-0.112	-0.389
	(0.716)	(-1.040)	(-0.249)	(-1.006)
Oil trade balance*Oil exporter	0.395**	0.061	0.409***	0.064
	(2.249)	(0.638)	(3.246)	(1.093)
Oil trade balance*Oil importer	0.747*	-0.220*	0.552**	-0.052
	(1.692)	(-1.850)	(2.403)	(-0.541)
Lagged dependent variable	0.059	0.092*	0.326***	0.087
	(0.441)	(1.835)	(5.977)	(1.366)
Lagged oil trade balance	-5.416*	0.823	-3.975***	-0.428
	(-1.839)	(0.912)	(-2.760)	(-0.738)
Constant	7.856***	6.118***	-0.530	0.073
	(7.499)	(8.659)	(-0.488)	(0.085)
Number of countries	15	15	15	15
Observations	993	993	1,560	1,538
Adjusted R-squared	0.146	0.016	0.375	0.060

CHAPTER 6
Conclusion

In this thesis, we examined whether the impact of local oil price shocks and global oil price shocks on stock market returns and exchange rates in oil-exporting countries is different from in oil-importing countries. First, we identified local oil price shocks by constructing the sources of changes in oil prices using Ready's (2018) approach. Local oil shocks were decomposed into three shocks: local supply shocks, local demand shocks and risk shocks. Second, global oil price shocks were constructed following Kilian's (2009) methodology using the SVAR model to disaggregate oil price shocks into three shocks: supply shocks, demand shocks and oil-specific demand shocks.

There are several important findings from the present analyses. First, we found that the impact of local and global oil price shocks is different depending on the level of oil import and export and the sources which drive oil price shocks (supply and demand shocks). For oil exporting countries, local demand shocks and global demand shocks have the same impact on stock market returns while local and global supply shocks have different impacts. We found that rises in oil prices driven by both local and global demand shocks have significant positive relationships with higher stock market returns. Moreover, local supply shocks also have significant positive impacts for all oil exporters in our sample, whereas global supply shocks had less significant impacts on stock market returns. For oil-importing countries, the results indicate that local demand shocks and global demand shocks generally cause higher stock market returns in all countries; however, the impact of local supply shocks and global supply shocks was inconclusive as we found both negative and positive impacts on stock market returns. A plausible explanation is that the impact depends on the level of oil dependence and the economic development of each country. It is noteworthy that local demand and supply shocks have much stronger impacts on stock market returns than global demand shocks in both oil-exporting and oil-importing countries.

Second, we investigated the impact of local and global oil price shocks on exchange rates. We detected significant negative effects in response to local demand and supply shocks in oil-exporting countries, which indicates U.S. dollar depreciation or appreciation of the oil exporters' currency. In the case of oil-importing countries, the impact of local demand shocks and local supply shocks led to a depreciation of the local currency. On the other hand, global supply shocks seem to have less of an effect on exchange rates in both oil-exporting and oil-importing countries.

Our results have important implications suggesting that the impact of local oil price shocks is greater than the impact of global oil price shocks on stock market returns and exchange rates. This suggests that domestic conditions such as government rules, level of oil production or level of oil reserve of each country have a significant impact and help to explain the dynamics of stock market returns and exchange rates. In addition, our results reveal the dynamics of stock market returns related to oil exporters and oil importers. The impact seems to be dominated by oil-exporting countries in our sample. This can help oil companies to manage oil-related risk. For example, local and global oil demand shocks have stronger and more persistent impacts on stock market returns in oil-exporting countries, while there is less of an impact in oil-importing countries. Thus, oil companies or market participants in oil-exporting countries should use financial instruments for hedging against changes in oil demand. In addition, our findings on the relationship between oil price shocks and exchange rates also provide useful information for investors or policy makers to understand the dynamics of exchange rates in response to oil price shocks.

Appendix A

Figure A.1: Historical decomposition of structural shocks constructed from Ready's (2018) methodology using monthly data

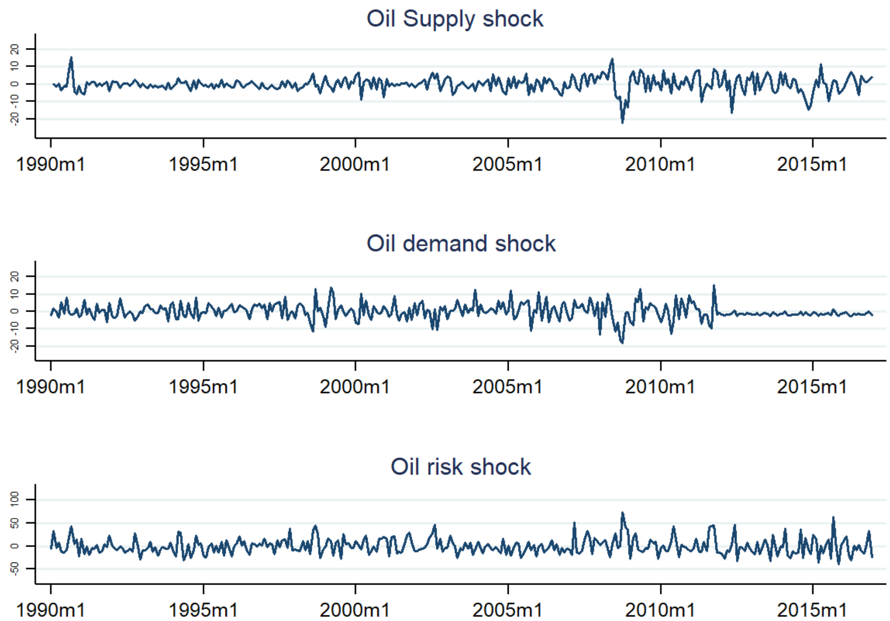
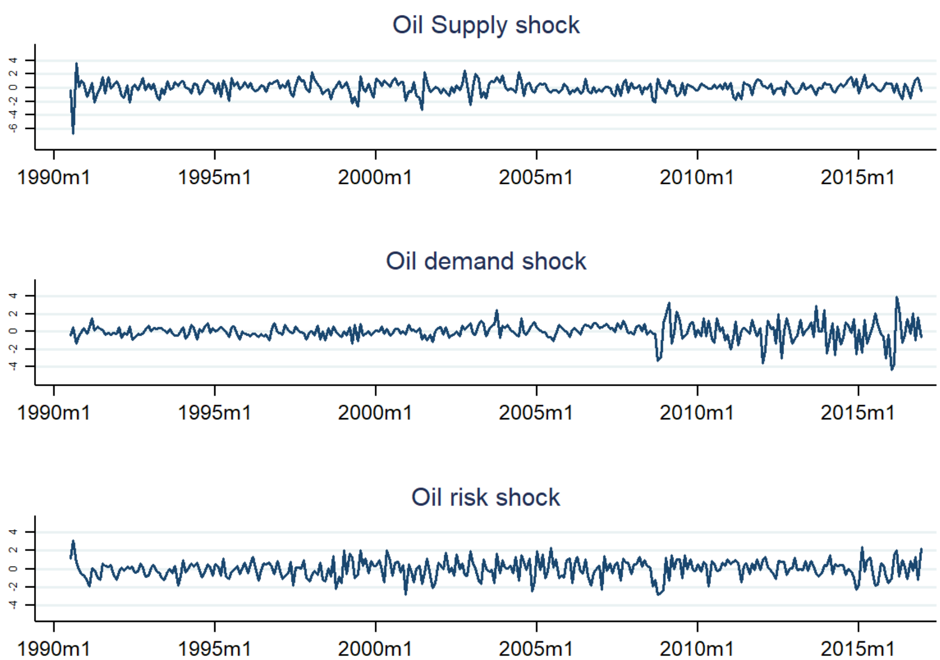


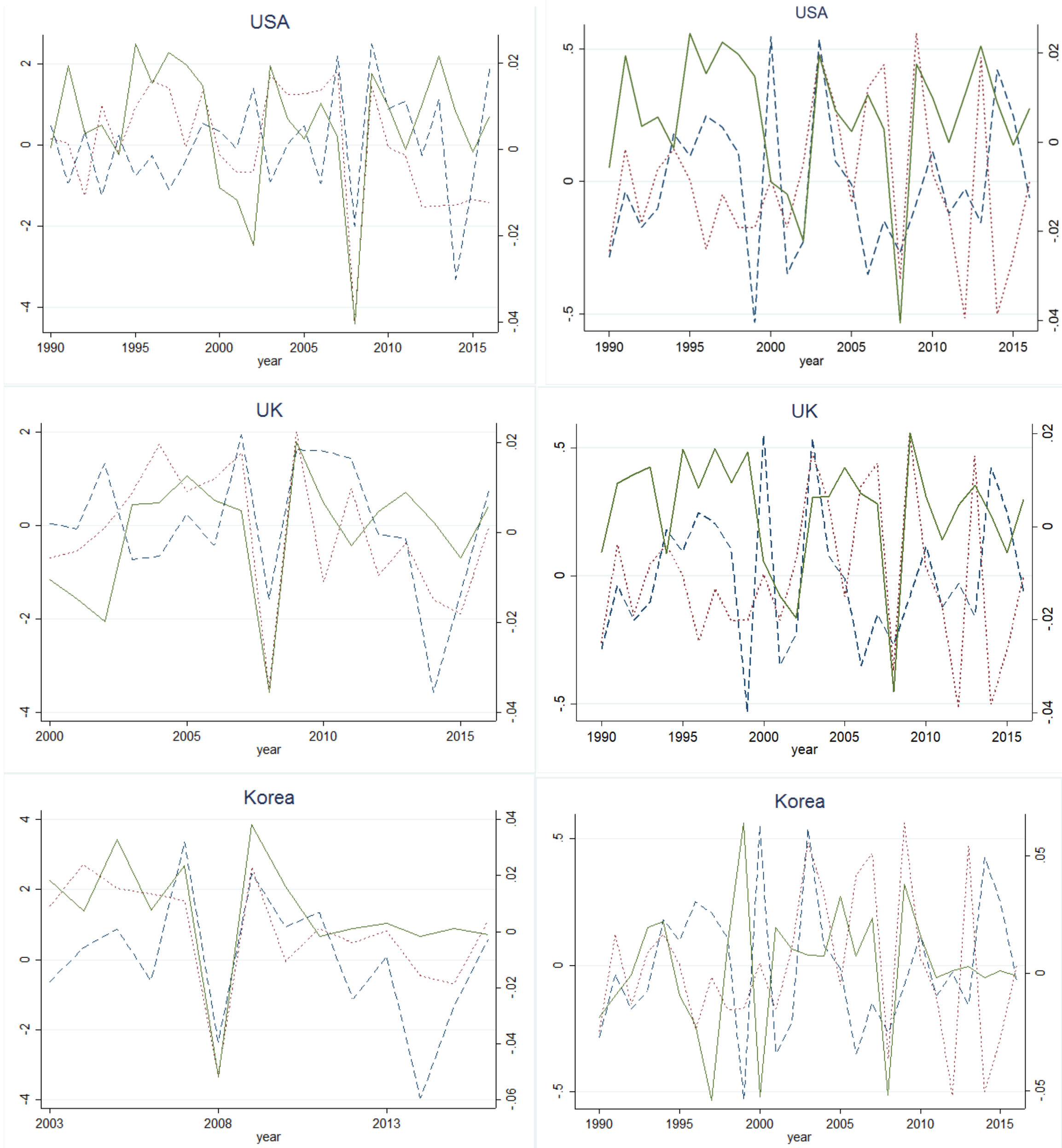
Figure A.2: Historical decomposition of structural shocks constructed from Kilian's (2009) methodology using monthly data



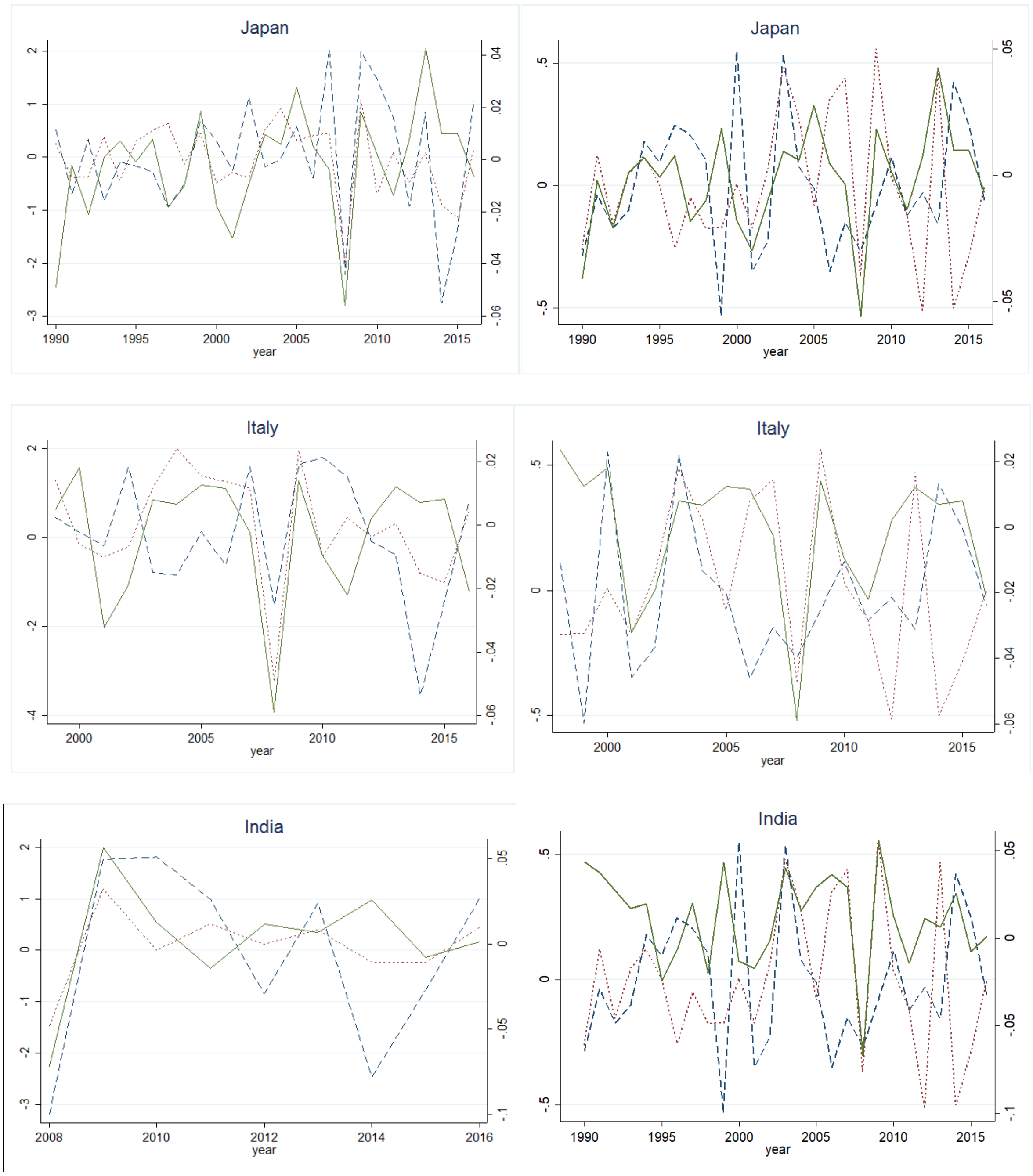
Appendix B

Figure A.3: Oil demand and supply shocks with stock market returns in each country
The blue dotted line represents supply shocks, the red dashed line is demand shocks and the green line represents stock market returns.

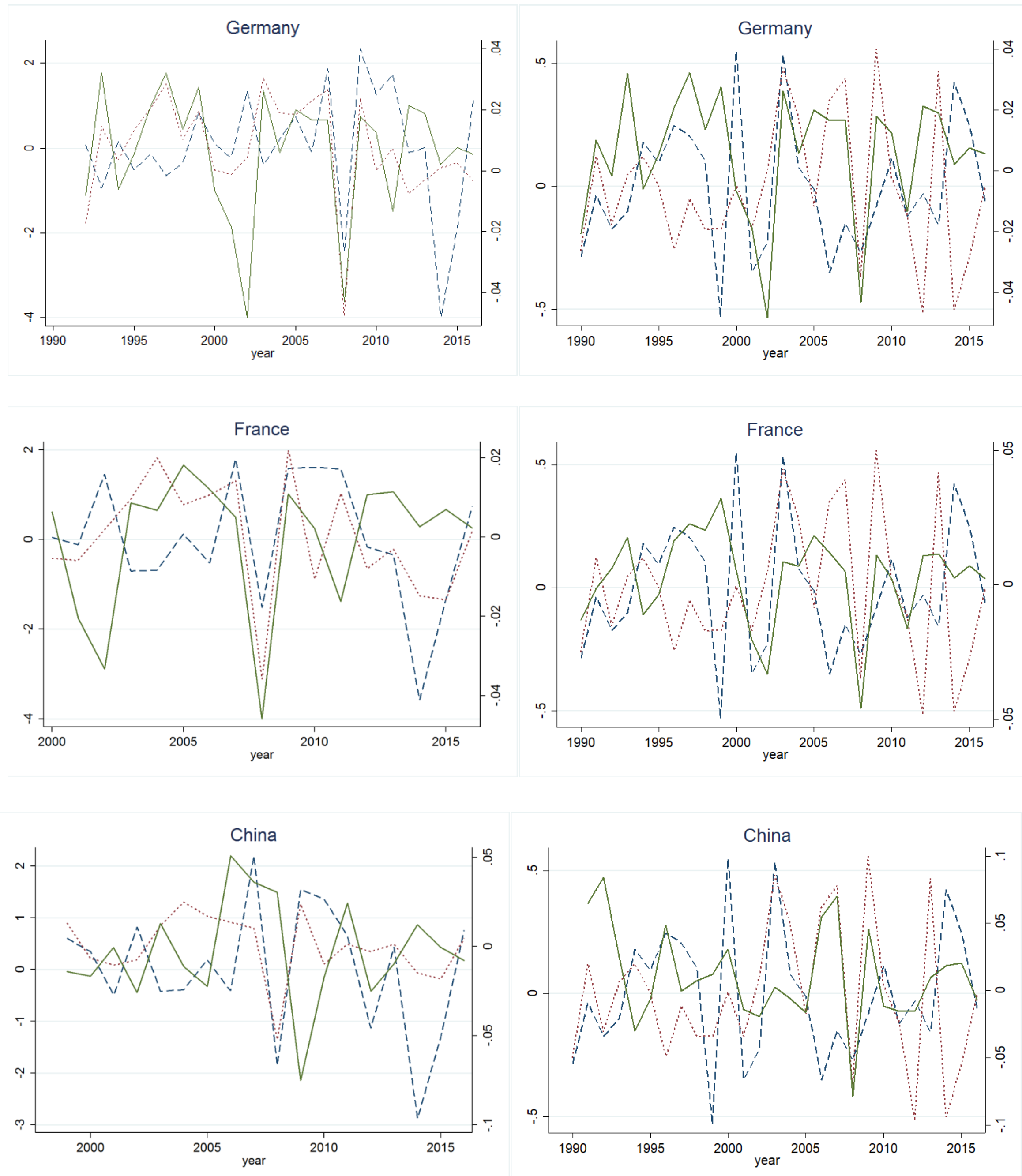
Local oil shocks | Global oil shocks



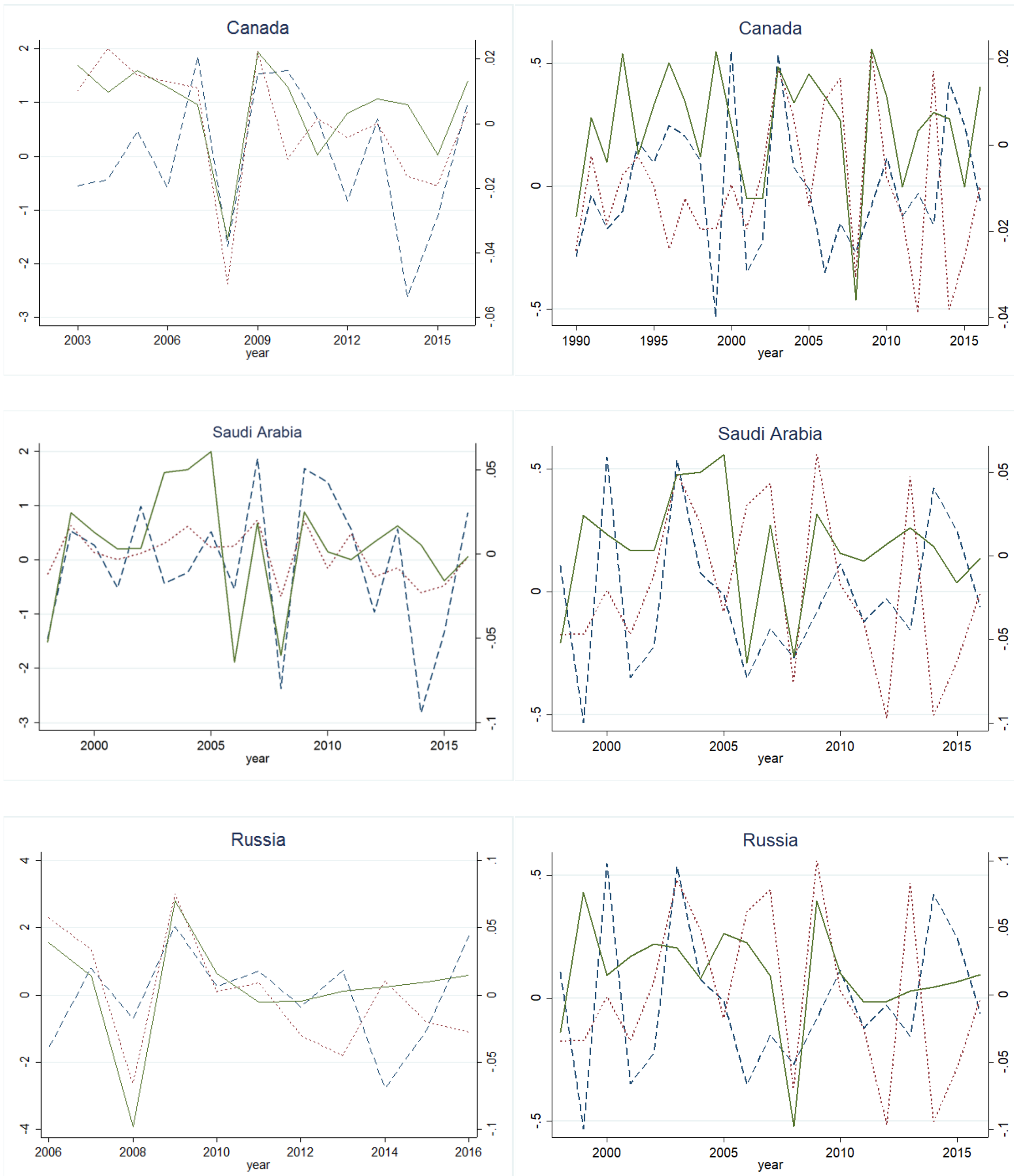
Local oil shocks　　　　Global oil shocks



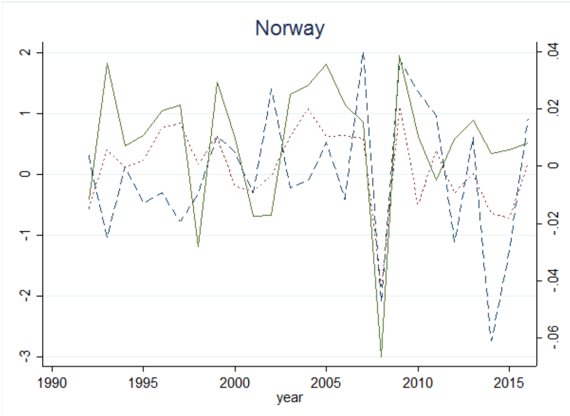
Local oil shocks | Global oil shocks

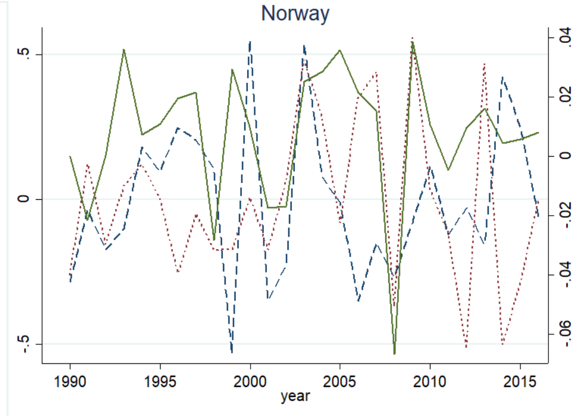


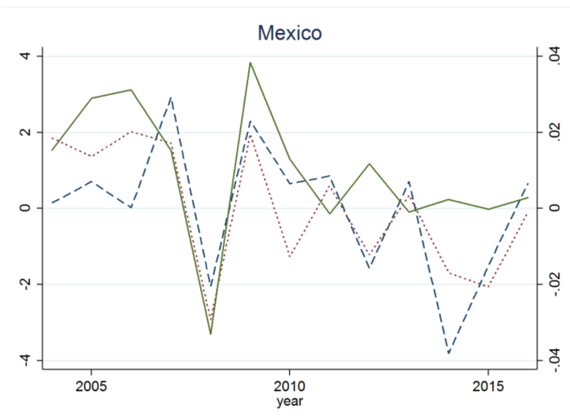
Local oil shocks | Global oil shocks

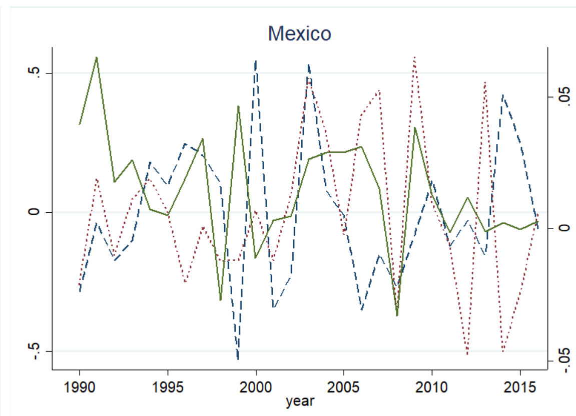


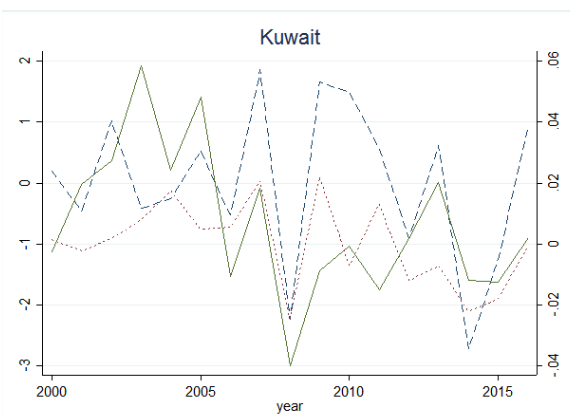
Local oil shocks	Global oil shocks

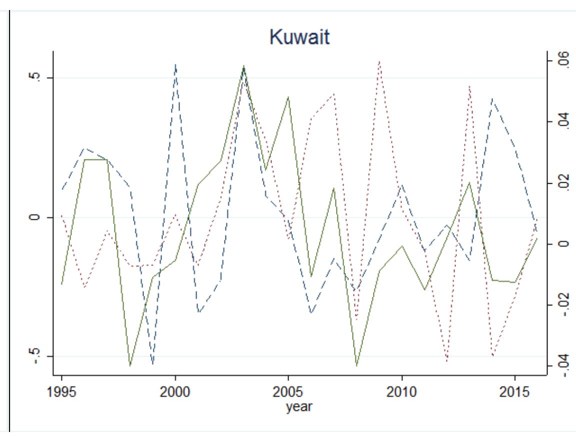












Appendix C

This appendix provides explanation of the volatility index (VIX) of each country. The volatility index measures the market expectation of short-term volatility. The Chicago Board Options Exchange (CBOE) introduced the CBOE Volatility Index (VIX) for U.S. markets in 1993 based on the S&P 100 index options. Then in 2003, CBOE revised the volatility index and changed it to be based on the S&P 500 index options.

The calculation of the VIX index is based on following formula:

$$\sigma^2 = \frac{2}{T}\sum_i \frac{\Delta K}{K_i^2} e^{RT} Q(K_i) - \frac{1}{T}\left[\frac{F}{K_0} - 1\right]^2 \tag{46}$$

Where

σ	is ${VIX}/{100}$ such that $VIX = \sigma \times 100$
T	Time to expiration
F	Forward index level from index option prices
K_0	First strike below the forward index level (F)
K_i	Strike price of out-of-the-money option at period i; a call if $K_i > K_0$; and a put if $K_i < K_0$; both put and call if $K_i = K_0$
ΔK	is ${K_{i+1} - K_{i-1}}/{2}$
R	Risk free interest rate to expiration
$Q(K_i)$	The midpoint of bid-ask spread for each option with strike K_i

Since the U.S. market introduced the VIX, other countries have developed volatility indices using their market index, calculated based on a formula for CBOE VIX methodology. This methodology can account for specific characteristics of the underlying index. Table A.1 reports details of the VIX, including the underlying index and methodology used to construct the index, for each country in our sample.

Table A.11: Detail on volatility index (VIX) for each country

Country	Underlying index	Methodology
U.S.	S&P 500 Index	CBOE
India	NIFTY 50 Index	CBOE
Japan	Nikkei 225 Index	CBOE
Korea	KOSPI 200 Index	CBOE
U.K.	FTSE 100 Index	CBOE
France	CAC 40 Index	CBOE
Germany	DAX Options Index	CBOE
Italy	FTSE MIB Index	CBOE
China	FTSE/Xinhua 25 Index	CBOE
Canada	S&P/TSX 60 Index Options	CBOE
Mexico	Mexican IPC Futures Index	Fleming et al. (1995)
Norway	OBX Total Return Index	CBOE
Kuwait	Kuwait Stock Market Index	Standard deviation
Saudi Arabia	Saudi Arabia Stock Index	Standard deviation
Russia	RTS Index Futures Contract	CBOE

As seen in Table A.1, most of the exchange markets followed the CBOE methodology for constructing the volatility index, except for Mexico; the Mexican volatility index (VIMEX) was constructed based on the methodology of Fleming et al. (1995) as follows:

$$VIMEX = \sigma_1\left(\frac{T_2-90}{T_2-T_1}\right) + \sigma_2\left(\frac{90-T_1}{T_2-T_1}\right) \tag{47}$$

Where

T_1 Calendar days remaining for the Option with the nearest quarterly maturity date

T_1 Calendar days remaining for the Option with the second nearest quarterly maturity date

σ_1 Variance of the nearest quarterly expiration date

σ_2 Variance of options series with the second nearest quarterly expiration date

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